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SWEEP OSCILLATORS

MODEL 6610ED- SERIES

(PLUG-INS)

INSTRUCTION MANUAL NO. 110-6024

SINGER
INSTRUMENTATION

INSTRUCTION MANUAL

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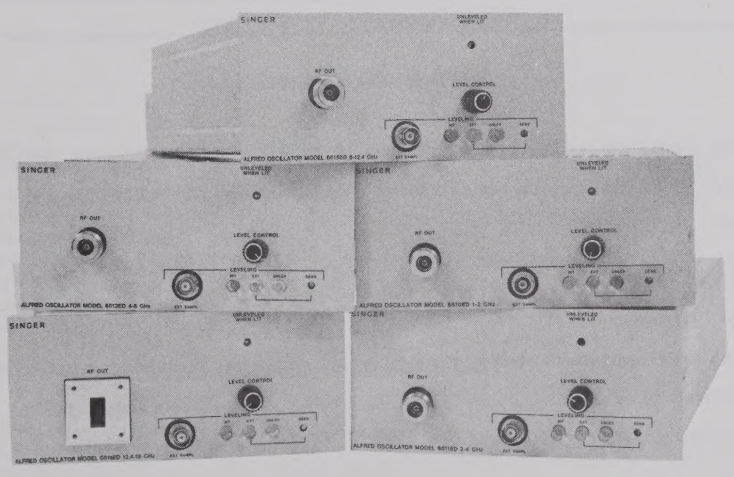

SINGER
INSTRUMENTATION

The Singer Company, Palo Alto Operation

3176 Porter Drive, Palo Alto, California 94304/ (415) 493-3231 TWX 910-373-1765

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THE SINGER COMPANY, PALO ALTO OPERATION, warrants each instrument sold by it to be free of defects in material and workmanship, effective from the date of shipment to the original purchaser for a period of 1 year except where a specific warranty period is stated in the operating manual. Microwave tubes used in standard instruments carry the best available service warranty, a copy of which is available on request.

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This warranty is expressly in lieu of any other warranties expressed or implied, including any implied warranty of merchantability, or fitness for a particular purpose, any other obligations or liability on the part of The Singer Company, and it neither assumes nor authorizes any other person to assume for it any other liability in connection with the sale of instruments manufactured by it.

SINGER
INSTRUMENTATION

The Singer Company, Palo Alto Operation, 3176 Porter Drive, Palo Alto, California 94304
Telephone: (415) 493-3231 TWX: 910-373-1765

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Instruments should be returned only on prior written authorization from the Singer Representative or the factory(1). Please provide the following information in order to expedite our processing of your instrument:

1. Model or Type
2. Serial Number
3. Approximate date instrument was placed in operation
4. Approximate number of hours of use
5. Description of trouble(2)
6. Has maintenance action been previously requested?
7. Other comments

Upon receipt of this information our Service Department will send you service data or shipping instructions. Upon receipt of shipping instructions forward the instrument prepaid to the specified center or factory. If requested, an estimate of charges will be made before work begins.

(1) West Coast Service Center, 3211 S. LaCienega Blvd., Los Angeles, California 90016, Telephone (213) 870-2761, TWX 910-340-6352 for all Singer Instrumentation equipment; or Palo Alto Operation, 3176 Porter Drive, Palo Alto, California 94304, Telephone (415) 493-3231 TWX 910-373-1765 for Palo Alto Operation instruments.

(2) Include data on symptoms, measurements taken, test instruments used, suspected location of trouble, maintenance action taken, and any other relevant data.

TABLE OF CONTENTS

Paragraph		Page
	SECTION I GENERAL INFORMATION	
1-1	General Description	1-1
1-5	Specifications	1-1
1-7	Equipment Supplied	1-1
	SECTION II OPERATION	
2-1	Incoming Inspection	2-1
2-3	Preliminary Inspections	2-1
2-5	Power Connection	2-2
2-7	Environment	2-2
2-9	Installation and Removal of 6610ED Plug-in Unit in the Model 6600(A)	2-2
2-10	Removing Plug-in Unit	2-2
2-12	Installing Plug-in	2-2
2-14	Frequency Dial Installation	2-2
2-15	Panel Controls and Connectors	2-2
2-17	Required Test Equipment	2-4
2-19	Minimum Performance Standards Tests	2-4
2-21	Operation	2-6
	SECTION III THEORY OF OPERATION	
3-1	General Functions of the Plug-in Unit	3-1
3-3	Detailed Operation of the Plug-in Unit	3-1
3-7	General Circuit Theory	3-2
3-9	Standard Circuits	3-2
3-15	Two-Stage Amplifiers	3-3
3-25	Integrated Circuits	3-5
3-27	Operational Amplifiers	3-5
3-35	Logic Circuits	3-7
	SECTION IV MAINTENANCE	
4-1	General	4-1
4-3	Troubleshooting	4-1
4-7	Component Locations	4-1
4-9	Parts Locations	4-1
4-11	Detail Circuit Descriptions	4-1
4-13	Sample Inverter, Master Board	4-1
4-16	Power Level Amplifier, Master Board	4-1
4-24	Modulation Amplifier, Master Board	4-12
4-28	Tuning Voltage Amplifier, Master Board	4-12
4-30	Frequency Modulation Amplifier, Master Board	4-12
4-32	NA Adapter Circuit	4-12
4-34	Adjustment Procedures	4-27
	SECTION V PARTS LIST	
5-1	Introduction	5-1
5-3	Ordering Information	5-1
5-5	How to use the Parts List	5-1
5-7	Circuit Reference	5-1
5-9	Description Column	5-1
5-11	Singer Part Number Column	5-1
5-13	True FSC Number Column	5-1
5-15	True Manufacturer's Part Number Column	5-1
	SECTION VI SCHEMATIC DIAGRAMS	
6-1	Supplementary Schematics by Module rather than by Function	6-0

LIST OF ILLUSTRATIONS

Figure No.		Page
1-1	Models 6610ED through 6616ED Series	1-0
2-1	Front Panel Model 6610ED	2-2
2-2	Rear Panel Connectors Model 6610ED Series	2-3
3-1	Signal Flow Models 6610ED through 6616ED	3-1
4-1	Top View of 6611ED Assembly Locations	4-7
4-2	Top View of 6612ED Master Board Removed Assembly Locations	4-8
4-3	Bottom View of 6611ED Assembly Locations	4-8
4-4	Sample Switching and Inverting	4-9/4-10
4-5	Leveling Amplifier	4-11/4-12
4-6	Sampling and Level Control Circuits	4-11/4-12
4-7	Amplitude Modulation Circuits	4-13/4-14
4-8	Tuning Voltage Amplifier	4-15/4-16
4-9	FM Amplifier	4-17/4-18
4-10	NA Adapter Circuit	4-17/4-18
4-11	RF Plate Schematic Models 6610ED, 6611ED	4-19/4-20
4-12	RF Plate Schematic Model 6612ED	4-21/4-22
4-13	RF Plate Schematic Model 6615ED	4-23/4-24
4-14	RF Plate Schematic Model 6616ED	4-25/4-26
6-1	Master Board Schematic	6-1/6-2
6-2	Front Panel Wiring A4, A5	6-3/6-4

LIST OF TABLES

Table No.		Page
1-1	Specifications	1-1
2-1	Preliminary Inspection Checks	2-1
2-2	Model 6610ED Front Panel Controls and Connectors	2-2
2-3	Model 6610ED Rear Panel Connectors	2-3
2-4	Recommended Test Equipment	2-4
2-5	Minimum Performance Standards Tests	2-5
4-1	Troubleshooting Procedures	4-2
4-2	Adjustment Procedures	4-27
5-1	Model 6610ED Series	5-2
5-2	Federal Supply Code for Manufacturers	5-2
5-3	Reference Symbols	5-2
5-4	Abbreviations	5-2
5-5	Replaceable Parts Model 6610ED Series	5-3
5-6	Replaceable Parts Peculiar to Model 6610ED	5-8
5-7	Replaceable Parts Peculiar to Model 6611ED	5-9
5-8	Replaceable Parts Peculiar to Model 6612ED	5-10
5-9	Replaceable Parts Peculiar to Model 6615ED	5-11
5-10	Replaceable Parts Peculiar to Model 6616ED	5-12
5-11	Replaceable Parts in Front Panel Assemblies	5-13

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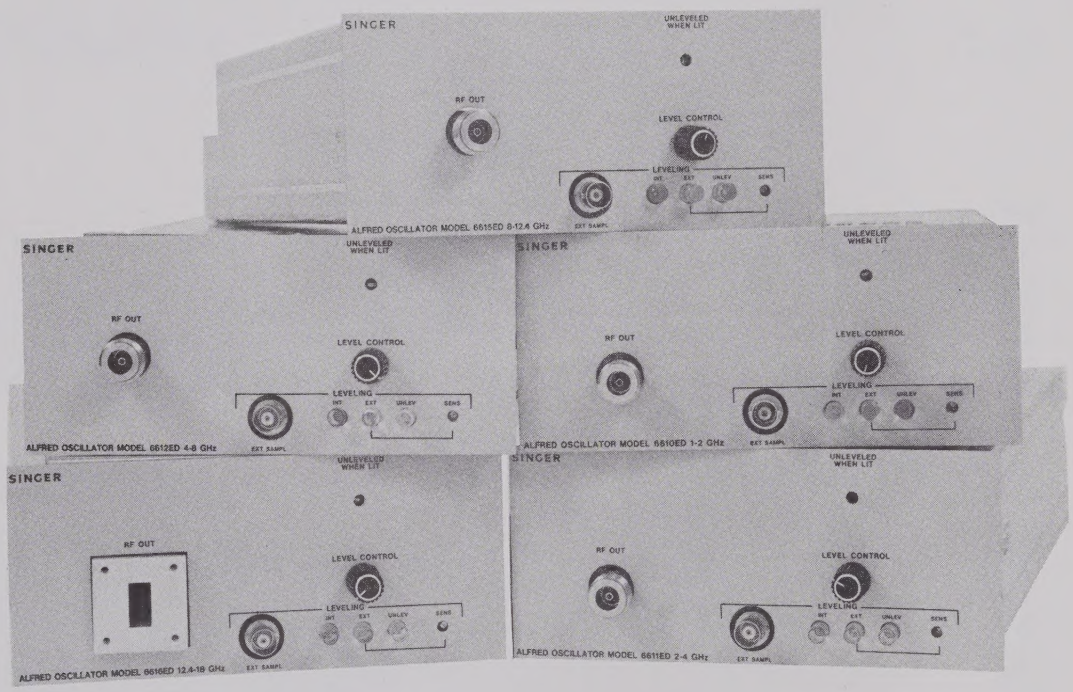


Figure 1-1. Models 6610ED through 6616ED Series

SECTION I
GENERAL INFORMATION

1-1. GENERAL DESCRIPTION.

1-2. Singer Models 6610ED, 6611ED, 6612ED, 6615ED, and 6616ED microwave signal generators (Figure 1-1), hereinafter referred to as 6610ED or 6610ED Plug-in Units are used in conjunction with the Singer Model 6600(A) Sweep Oscillator. Therefore, the description contained herein assumes that the Plug-in Unit is installed in the Model 6600(A) Sweep Oscillator main frame. The Plug-in Units are RF solid-state oscillator units designed to operate with the Model 6600(A) Sweep Oscillator. The Plug-in Units operate in the frequency range of 1 to 18 GHz.

1-3. The frequency ranges can be swept tuned or tuned to a specific frequency. Frequency tuning is accomplished by the Model 6600(A) using the frequency dial plate furnished with the Plug-in Unit. The RF output can be leveled internally or externally as selected by front panel control. Provision is made to amplitude modulate the RF output from an external source and from internal square wave. Frequency modulation from an external source is also provided.

1-4. The information contained in this manual is current only to the date of publication. Differences in equipment configuration, components, specifications and performance resulting from customer application requirements and/or the Singer Company's continuous product improvement program are described on Manual Change Sheets.

1-5. SPECIFICATIONS.

1-6. The electrical and physical specifications of the Plug-in Units are listed in Table 1-1.

1-7. EQUIPMENT SUPPLIED.

1-8. The equipment supplied with each Plug-in Unit consists of a dial faceplate:

Plug-in Unit	Dial Faceplate Singer Part Number
6610ED	942-405-08
6611ED	942-405-09
6612ED	942-405-13
6615ED	942-405-06
6616ED	942-405-07

TABLE 1-1. SPECIFICATIONS

MODELS	6610ED	6611ED	6612ED	6615ED	6616ED
FREQUENCY CHARACTERISTICS					
Frequency Range:	1 - 2 GHz	2 - 4 GHz	4 - 8 GHz	8 - 12.4 GHz	12.4 - 18 GHz
Frequency Accuracy:	± 10 MHz	±15 MHz *	±15 MHz	±40 MHz	±50 MHz
Residual FM:	<7 kHz pk	<7 kHz pk	<15 kHz pk	<15 kHz pk	<25 kHz pk
Stability: With change in power level:	±1 MHz (10 dB)	±1 MHz (10 dB)	±1 MHz (10 dB)	±1 MHz (10 dB)	±2 MHz (10 dB)
OUTPUT POWER CHARACTERISTICS					
Leveled Power (min):	20 mW	10 mW	5 mW	6 mW	4 mW
Internally Leveled Power Variations:	±0.5 dB	±0.5 dB	±0.8 dB	±0.7 dB	±1 dB
Leveled Power Control Range: Approx.	10 dB	10 dB	10 dB	10 dB	10 dB
Spurious Signals: Harmonics:	>-20 dB	>-20 dB	>-17 dB	>-30 dB	>-30 dB
Non-Harmonics:	>-50 dB	>-50 dB	>-50 dB	>-50 dB	>-50 dB
RF Sampler (For external sampling only):	1173-10-2	1173-10-2	1176-10-2	1176-10-2	

* For 6600 Spec. 1935, Frequency Accuracy on CW is ± 10 MHz

TABLE 1-1. SPECIFICATIONS (CONTINUED)

MODELS	6610ED	6611ED	6612ED	6615ED	6615ED
AM CHARACTERISTICS					
External Pulse On/Off AM:					
On/Off Ratio:	> 50 dB	> 50 dB	> 50 dB	> 50 dB	> 50 dB
External PM AM:					
Leveled:					
Rise Time:	< 6 μsec	< 6 μsec	< 6 μsec	< 6 μsec	< 6 μsec
Unleveled:					
Rise Time:	< 100 nsec	< 100 nsec	< 100 nsec	< 100 nsec	< 100 nsec
Frequency Response:	DC-1 MHz	DC-1 MHz	DC-1 MHz	DC-1 MHz	DC-1 MHz
Modulation Sensitivity:	-1 V/40 dB	-1 V/40 dB	-1 V/40 dB	-1 V/40 dB	-1 V/40 dB
FM CHARACTERISTICS					
External FM or Phase Lock:					
Max. Deviation for following Modulation rates:					
DC - 100 kHz	± 25 MHz	± 25 MHz	± 25 MHz	± 10 MHz	± 10 MHz
DC - 1 MHz	± 5 MHz	± 5 MHz	± 5 MHz	± 1 MHz	± 1 MHz
Modulation Sensitivity (Nominal):	4 MHz/V	4 MHz/V	4 MHz/V	2 MHz/V	2 MHz/V
OUTPUT CONNECTOR:	N Female	N Female	N Female	N Female	WR-62 (vertical)

SECTION II
OPERATION

2-1. INCOMING INSPECTION.

2-2. The Plug-in Units are shipped ready for use. Unpack and check the contents of all shipping containers against the packing invoice to be sure the order is complete. Check the unit for shipping damage. The front panel controls should move easily, with full travel and positive detents. Note any mechanical damage, and check the condition of accessories shipped with the unit. If there is any damage or deficiency, or if electrical performance is not within specifications, see the warranty inside the front cover of this manual.

2-3. PRELIMINARY INSPECTIONS.

2-4. Preliminary inspection of the equipment is performed on the Plug-in Unit without operating power applied. This type of check is designed to detect conditions that might otherwise lead to a breakdown. Frequent causes of premature failure are overheating, due to improper ventilation or accumulation of dust and dirt, and/or loose connections and fittings. Inspection is carried out with emphasis on finding evidence of these conditions. Table 2-1 lists the preliminary inspection checks for the equipment.

TABLE 2-1. PRELIMINARY INSPECTION CHECKS

Item	Inspect For	Corrective Action
Connectors	Looseness, bent or corroded contacts, signs of arcing	Clean contacts with cloth moistened with cleaning solvent trichloroethylene or equivalent.
		Replace connectors if damaged or deeply corroded.
Main Frame and front panel	Dirt and corrosion	Clean with cloth moistened with cleaning solvent trichloroethylene or equivalent.
Knobs, screws, connectors, clamps	Looseness	Tighten using appropriate torque so as not to strip threads.
Switches	Looseness	Tighten mounting screws or nut.
Wiring	Looseness	Resolder, recable, or reclamp.
	Frayed, worn, or missing insulation	Replace as required.
Solder joints	Loose or cold solder connections; corrosion	Clean carefully and resolder, using recommended soldering iron.
Printed circuit boards	Mounting looseness	Replace mating plug if required.
	Loose components	Resolder loose components.
Resistors	Cracks, chipping, blistering, discoloration, and other signs of overheating	Replace with exact match or original.
Capacitors	Leaks, bulges, signs of aging	Replace capacitor.
	Loose mounting bracket	Tighten nuts or screws holding bracket.
Switch contacts	Dirt, dust, and/or corrosion	Clean with cloth, aerosol spray, syringe or camel-hair brush using trichloroethylene or equivalent.
	Bent or broken contacts	Replace switch wafer or assembly.
Transistors	Looseness	Seat firmly in sockets, or resolder leads to etched circuit.

2-5. POWER CONNECTION.

2-6. All power is supplied by the 6600(A) Main Frame.

2-7. ENVIRONMENT.

2-8. The 6610 Plug-in Unit is always used as part of the 6600(A) Main Frame Assembly. Refer to the 6600(A) Manual for environment notes.

2-9. INSTALLATION AND REMOVAL OF 6610ED PLUG–IN UNIT IN THE MODEL 6600(A)

CAUTION

When changing Plug-in Unit, turn the POWER switch off and wait 15 seconds before removing the Plug-in Unit, to permit decay of the power supply voltages. Do not insert 6610 Plug-in Unit into the 6600(A) with 6600(A) power turned ON.

2-10. REMOVING PLUG-IN UNIT.

2-11. Pull out the black lever at the left of the Plug-in. This will cause the Plug-in to move out of the 6600(A) panel. Remove the Plug-in by holding the edges of its front panel and pulling out of the 6600(A).

2-12. INSTALLING PLUG-IN.

2-13. Press down and hold the black lever at the left of the Plug-in receptacle in the 6600(A). Push the Plug-in into the receptacle until the black lever is forced up a little. Push the black lever up to be almost flush with the 6600(A) and Plug-in panels. The front panels should be flush.

2-14. FREQUENCY DIAL INSTALLATION.

a. Select the frequency scale corresponding to the range of the appropriate plug-in unit.

b. Place the beveled edge at the left end of the frequency scale under the lip at left end of the Model 6600(A) frequency dial.

c. The corresponding lip at the right end of the Model 6600(A) frequency dial is spring-loaded. Slide it about 1/4 inch to the right, and place the frequency scale in position over the frequency dial.

d. Release the sliding lip and check to be sure that the scale is secure. There is a calibration line on the frequency scale. This should coincide with two dots on the 6600(A) frequency dial. If it does not, adjust its position by turning the screw head to the left-center of the frequency scale.

2-15. PANEL CONTROLS AND CONNECTORS.

2-16. The front panel operating controls and connectors are described in Table 2-2 and illustrated in Figure 2-1. The rear panel operating controls and connectors are described in Table 2-3 and illustrated in Figure 2-2.

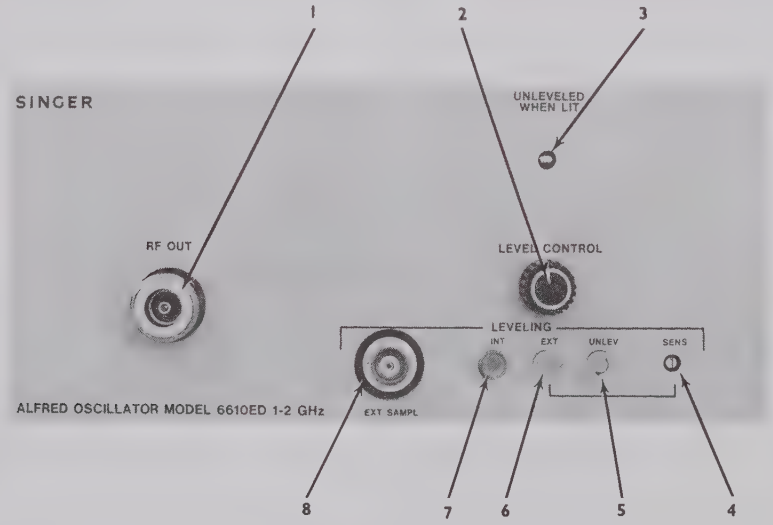


Figure 2-1. Front Panel Model 6610ED

TABLE 2-2. MODEL 6610ED FRONT PANEL CONTROLS AND CONNECTORS

1	RF Output Connector	5	Unleveled Operation Selector
2	RF Level Control	6	External Leveling Selector
3	Unleveled When Lit Indicator	7	Internal Leveling Selector
4	External Leveling Sample Sensitivity Control	8	External Leveling Sample Input Connector

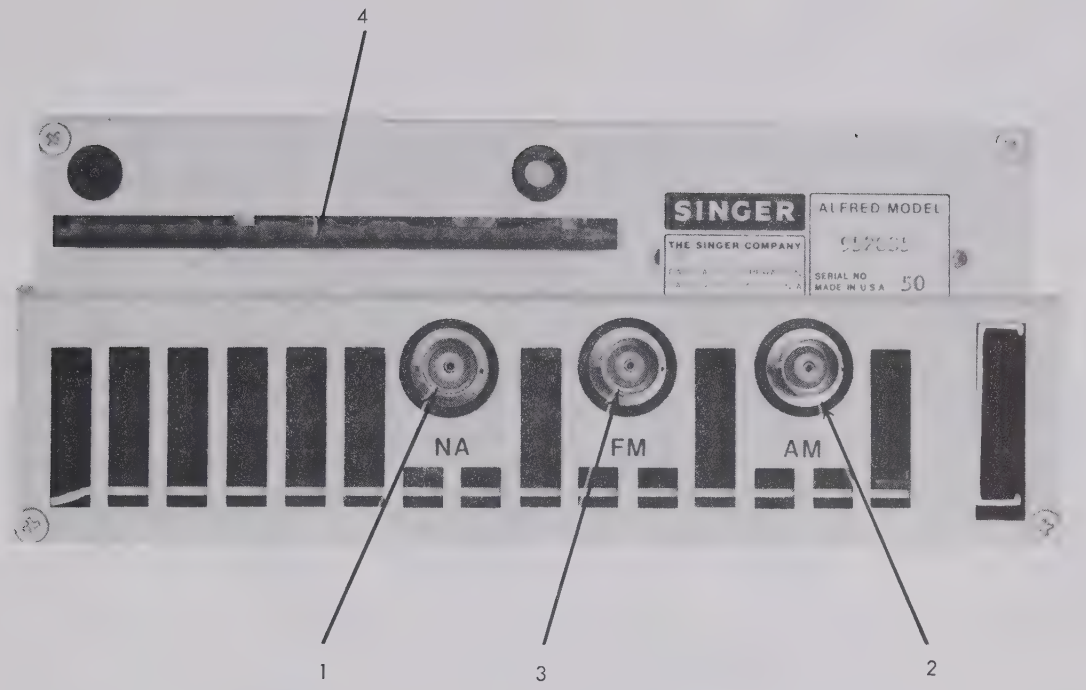


Figure 2-2. Rear Panel Connectors 6610ED Series

TABLE 2-3. MODEL 6610ED REAR PANEL CONNECTORS

1	NA Connector: Voltage proportional to frequency.

Model	Max. Frequency Voltage
6610ED	+40.00
6611ED	+40.00
6612ED	+40.00
6615ED	+22.00
6616ED	+18.068

2	AM Input External Amplitude Modulation is provided through the plug-in rear panel "AM" jack which is connected through the leveling circuit to a PIN modulator. Rise times of less than 100 nsec are achievable. Minus 5 volts modulates power from on to off. For off to on modulation, simply turn power level control to off position and apply +5 volts. The amplitude of the unleveled output power can be continuously varied at rates from DC to above 1 MHz. Because the "AM" jack is inside the leveling loop, modulating signals of less than 10 kHz will have reduced effect if applied during leveled operation. Modulation signals can be applied simultaneously to the "PM" and "AM" jacks.
3	FM Input External Phase Lock and Fast Rate FM are available through the plug-in rear panel "FM" jack. Offered previously to phase lock the 6600 to any of the leading synchronizers, the "FM" jack can also be used for frequency modulations from DC to above 1 MHz. However, in contrast to the J1 connector which can sweep full range, the "FM" jack is limited to deviations of less than 60 MHz peak to peak. FM signals can be simultaneously applied to "FM" and "J1". Limited bandwidth phase locking of plug-ins without the FM jack is accomplished through the external sweep J1 connector.

2-17. REQUIRED TEST EQUIPMENT.

2-18. The test equipment required for performance testing, calibration, adjustment and troubleshooting is listed in Table 2-4. Other test equipment can be used if its performance equals or exceeds the critical specifications given.

2-19. MINIMUM PERFORMANCE STANDARDS TESTS.

2-20. The performance tests in Table 2-5 verify that the instrument operates as specified; they can be used for incoming inspection or for periodic calibration. Access to the instrument interior is not required. The tests must be performed with the plug-in and oscillator installed in a properly calibrated Model 6600(A) Sweep Oscillator. If the plug-in and oscillator unit fails to meet any of the specifications, either return the instrument to the factory or recalibrate the instrument according to the procedure provided in the Adjustment and Calibration Procedures. If a malfunction occurs in the plug-in or oscillator unit, troubleshoot and adjust as necessary.

TABLE 2-4. RECOMMENDED TEST EQUIPMENT

Test Equipment	Critical Specifications	Manufacturer and Model
Network Analyzer	At least 100 kHz to 18 GHz, -40 dBm to +20 dBm	SINGER 8000/7051
Frequency Counter	At least 100 kHz to 18 GHz, Sensitivity < 4 mW.	Systron-Donner 1038/1253
Oscilloscope	Sweep from < 10 msec to > 60 sec, External Trigger	Tektronix 531Z/533A
Oscilloscope Plug-in	Sensitivity: 50 mV or less/cm Frequency: DC to 10 MHz	Tektronix Type 1A1
Power Meter and Thermistor Mount	Power range: 100 μW to 10 mW	HP431 with 478A Thermistor Mount
Digital Voltmeter	Accuracy ±0.004%, 1 mV - 200V	HP3460
Crystal Detector Set	10 MHz - 12.4 GHz, matching Singer model 8000/7051	SINGER 1403
Directional Couplers	10 - 1000 MHz, 10 dB 1.0 - 4.2 GHz, 10 dB 3.0 - 12.4 GHz, 10 dB	SINGER 1170-10-2 SINGER 1173-10 SINGER 1176-10
Marker Generator	100, 25 and 5 MHz Marker	SINGER 7300
Pulse Generator	Rise and Fall time: < 13 nsec Rep. rate: 10 Hz to 10 MHz	HP241A
Coaxial Attenuator	20 dB ±1 dB, 10 MHz to 18 GHz	Narda 757
Service Kit for Model 6600(A) Containing:		
1 - Model 6602 Test Plug-in	To match 6600(A), with voltage switching and loads	103-2701-001
1 - Model 6602A Extender Plug-in	To match 6600(A) and Plug-ins	952-910
1 - PCB Extender, non-heatsink	To match non-regulator PCB's of 6600(A)	103-2230-001
1 - PCB Extender, heatsink	To match A2, A3 of 6600(A)	103-2231-001
2 - Extension Cables DIP connectors	DIP plugs on 12" flat cable	102-9205-001
1 - Extension cable, Power Supply	Male, female cable to match A1	102-9206-001

TABLE 2-5. MINIMUM PERFORMANCE STANDARDS TESTS

Step	Purpose	Procedure	Acceptable Indication
1	Verification of maximum leveled power output	a. Install the Model 6610ED Series Plug-in in the Model 6600(A) Sweep Oscillator in accordance with paragraph 2-9, and set controls as follows: Model 6600(A) controls: POWER — OFF FUNCTION — M1→M2 SWEEP TIME — 1.0 SEC SWEEP TRIGGER — INT MODULATION — OFF M1 and M2 — Band Limits F_o — Band Center ΔF — Any Position Plug-in Unit Controls: LEVELING — INT POWER SET — Fully CW ATTENUATOR — 0 dB	
		b. Set POWER switch to ON, and allow 30 minutes warm-up prior to performing test.	
		c. Connect the power meter through the 20 dB pad to the RF connector on the 6610ED Series Plug-in.	
		d. Adjust the LEVEL CONTROL for maximum leveled power output.	
		e. Note the output power level.	Refer to specification Table 1-1 for the appropriate ED series oscillator.
		f. Vary POWER SET control position.	Power level control range should be > 10 dB.
2	Verification of maximum unleveled power variation	a. Press LEVELING EXT pushbutton, plus or minus.	Power variations from minimum to maximum should not exceed 6 dB.
		b. Note variations in power output.	
3	Verification of internal leveled power variation	a. Press LEVELING INT pushbutton.	Leveled output variation across the band should not exceed ±0.5 dB.
		b. Rotate LEVEL CONTROL to full ccw.	
		c. Note variations in power output.	
4	Verification of external leveling	a. Disconnect the network Power Meter and 20 dB attenuator from the RF Jack.	
		b. Connect the directional coupler to the RF jack.	
		c. Connect the network analyzer to the directional coupler direct output.	
		d. Connect the RF detector to the attenuated output of the directional coupler.	
		e. Connect the output of the RF detector to the external sample input of the Plug-in Unit.	
		f. Set 6600(A) sweep selector to INT SWEEP TRIGGER.	

TABLE 2-5. MINIMUM PERFORMANCE STANDARDS TESTS (CONTINUED)

Step	Purpose	Procedure	Acceptable Indication
4	Verification of external leveling (continued)	g. Press the LEVELING EXT pushbutton and set the side panel switch, S4 EXT LEVELING to the proper polarity.	
		h. Adjust the LEVELING SENS control for best leveling. Use network analyzer as power variation meter.	External leveling should be < ±0.1 dB plus coupler variation.
5	Verification of residual FM	a. Disconnect the directional coupler from RF jack.	
		b. Connect spectrum analyzer to RF jack.	
		c. Press LEVELING INT button of the Plug-in Unit.	
		d. Set the 6600(A) sweep selector to CW position.	
		e. Measure the FM at the low band, center band and high band.	See plug-in specifications in Table 1-1, for the application plug-in.

2-21. OPERATION.

2-22. Install the desired Plug-in Unit in the 6600(A) Main Frame (paragraph 2-9), and turn the Main Frame power ON. On the 6600(A), set the sweep limit frequencies M1 or M2 to the desired output frequency. Set the ATTENUATOR, dB for the desired signal level. Maximum level output is 50 mW minimum for 6610ED, 30 mW for 6611ED, 40 mW for 6612ED, 4 mW for 6615ED, and 1 mW for 6616ED.

2-23. For general operating instructions, see the Manual for Model 6600(A) Main Frame. The 6610ED Series Plug-in Units supply RF power, attenuation of RF, and leveling of RF power over the frequency range of 1.0 GHz to 18.0 GHz. All other functions are controlled by the 6600(A).

SECTION III
THEORY OF OPERATION

3-1. GENERAL FUNCTIONS OF THE PLUG-IN UNIT.

3-2. These instructions assume that the Plug-in will be installed in the Model 6600(A) Sweep Oscillator Main Frame. With the Plug-in Unit installed in a Model 6600(A), the Plug-in Unit supplies fixed or swept frequency RF over the range of the Plug-in Unit. A detected sample of RF are accepted from external sources to level the swept output. Amplitude and frequency modulation circuits are provided.

3-3. DETAILED OPERATION OF THE PLUG-IN UNIT.

NOTE

This description of operation of the instrument is NOT provided for troubleshooting use. With the Block Diagrams provided, it tells how the instrument is connected to change signal inputs into the desired signal outputs. For specific signal tracing and troubleshooting, see Section IV, which shows detailed schematics of single functions, with indications of signal flow, voltages and waveforms. This section only gives the reader an understanding of how the instrument operates.

3-4. The primary assembly of the Plug-in Unit is the YIG Tuned Oscillator which produces RF at the desired frequency. Frequency is controlled by the Tuning Voltage Amplifier, across the full band of available frequencies. The tuning signals from the 6600(A) Main Frame control the frequencies and timing of the RF output. The Frequency Modulation Amplifier controls frequency within a relatively narrow band (approximately 60 MHz) centered on the frequency selected by the Tuning Voltage Amplifier. Input to the Frequency Modulation Amplifier is from the FM connector on the rear panel of the Plug-in Unit.

3-5. The RF signal produced by the YIG oscillator is fed through a PIN diode attenuator to the RF output connector on the Plug-in Unit front panel. The attenuator provides amplitude modulation of the signal. An internal sample of the signal fed through the attenuator is fed back through switching to the Power Level Amplifier, which controls the attenuator to provide a constant level of RF output. The sample signal may also be detected externally by either a positive or a negative detector. The detected signal is inverted if it is positive and the signal is fed to the Power Level Amplifier when external leveling is chosen. A manual power level control provides steady bias to allow control of either leveled or unleveled output power.

3-6. Amplitude modulation is provided by the Modulation Amplifier and by direct connection of external AM to the PIN diodes. Modulation may be by blanking pulses, RF marker pulses which increase amplitude momentarily, by an internal square wave, by external sine or square waves, or by a combination of the modulating signals. If leveling is chosen, the peak powers of pulses and square waves are held constant at frequencies well below 10 kHz. Above this frequency, the leveling signals are bypassed so that peak powers depend on the power vs. frequency characteristics of the basic YIG oscillator.

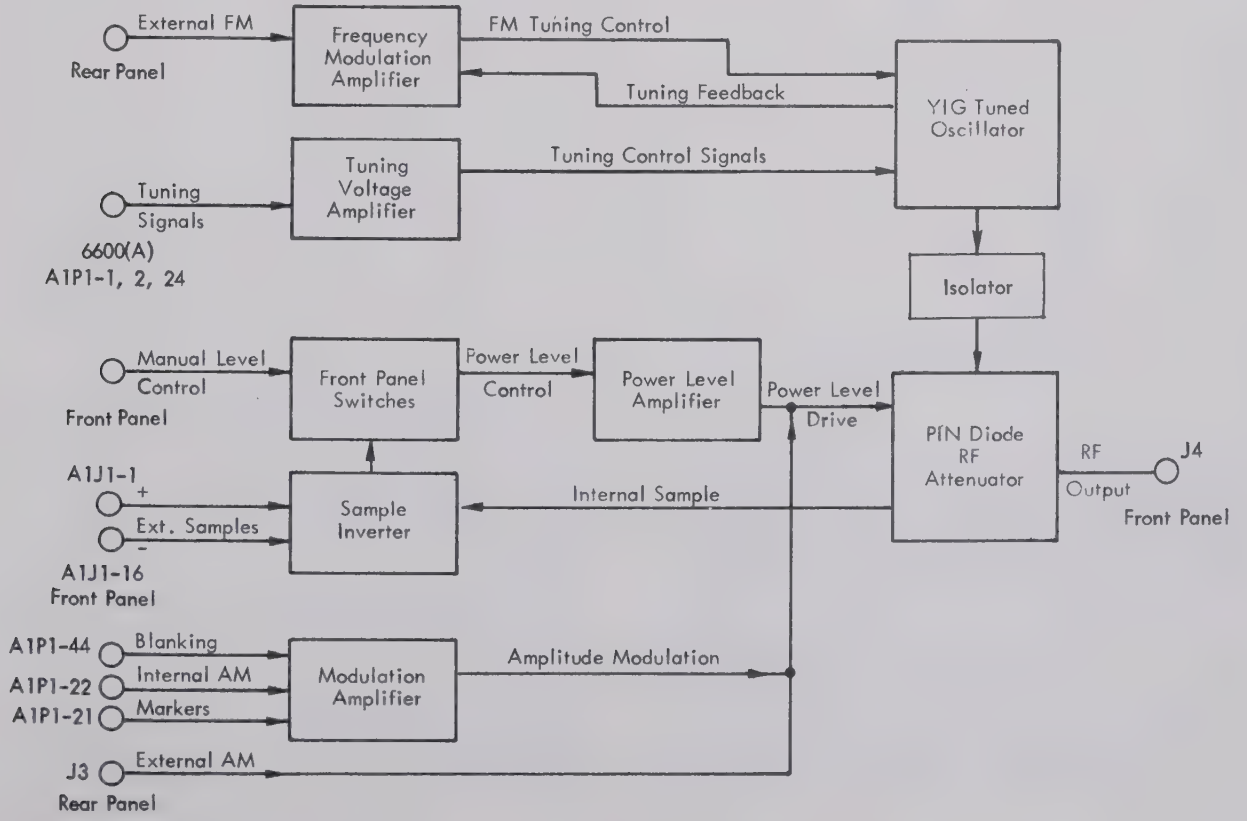


Figure 3-1. Signal Flow Models 6610ED Through 6616ED

3-7. GENERAL CIRCUIT THEORY

3-8. Singer Instruments are formed, principally, of standard semiconductor circuits which are in common use. A few special circuits are used repeatedly. These two classes of circuits are described in detail immediately hereafter. Some special circuits are used once or twice only. These circuits are described in detail, in Section 4 as the detailed circuit description, in order of signal flow, reach those particular circuits.

3-9. STANDARD CIRCUITS.

3-10. The circuits in Figure 1 use PNP (circuitA) and NPN (circuit B) transistors to convert low-level low-impedance signals to high-level high-impedance signals at higher levels of power. Signals into the input of each circuit cause current to flow in the input resistors. As the input voltage goes

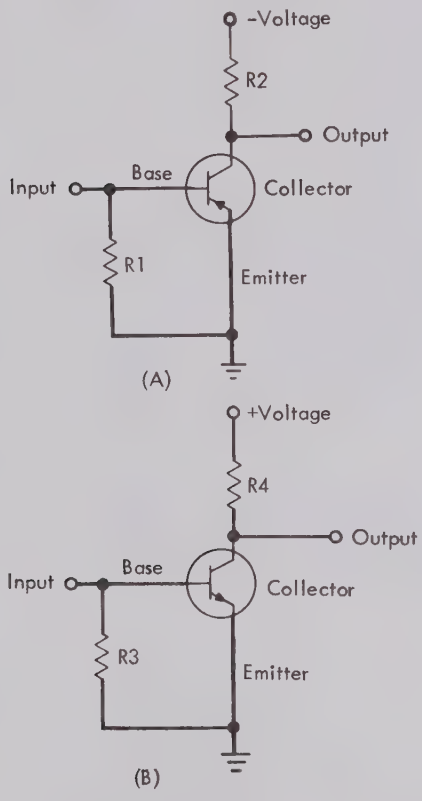


Figure 1. Common Emitter Amplifiers

negative (A) or positive (B), current flows in the base of the transistor. This allows current to flow between collector and emitter, in an amount equal to B times the base current. The collector current causes voltage drop across the collector resistor. The collector offers high impedance to current flow (a large change in collector-emitter voltage causes only a small change in collector current). Hence

$$E_C = B\, i_b\, R_C$$

Where E_C = Voltage across Collector Resistor, R_C

B = Current Gain of Transistor

i_b = Current in Base of Transistor

For low impedance into the base (usually around 1 kΩ) and high impedance at the collector, possible power gain is usually 25 dB to 40 dB or more. Polarity of the voltage changes are, of course, reversed from base to collector. These circuits will be called common emitter amplifiers.

3-11. The two circuits in Figure 2 use PNP (circuit A) and NPN (circuit B) transistors to convert medium-to-high level medium-impedance signals to medium-to-high level low-impedance signals at higher levels of power. The base of

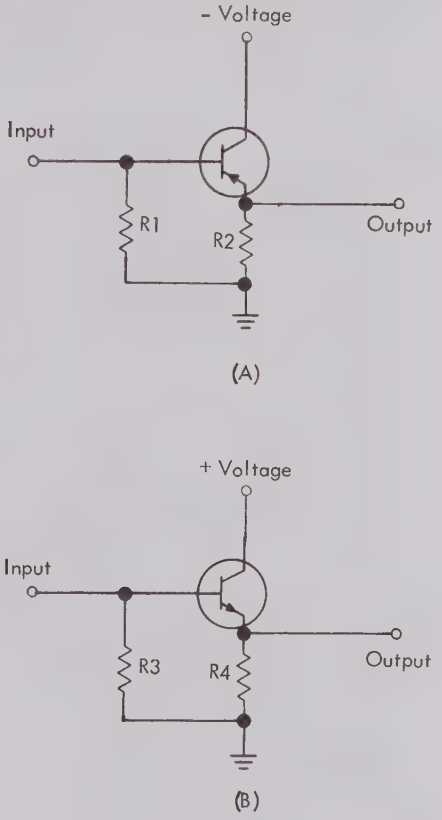
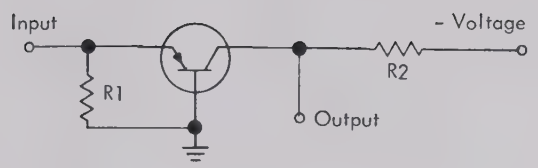


Figure 2. Emitter-Follower Amplifiers

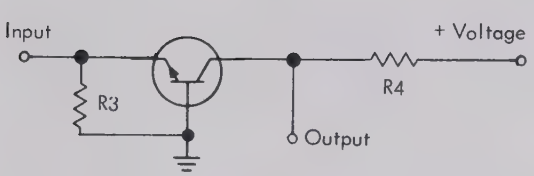
of each transistor offers an impedance-to-input of B times the emitter resistor value, plus approximately 1 kΩ. Current in the emitter is equal to the base current times (B+1), the B representing collector current, the "1" representing base current. Impedance level of the emitter is equal to impedance of the circuit driving the input divided by (B+1).

3-12. In this circuit there is a slight loss of voltage variation, from input to output. Possible power gain is usually from 20 dB to 30 dB. These circuits will be called emitter followers.

3-13. The two circuits in Figure 3 use PNP (circuit A) and NPN (circuit B) transistors to convert currents from a low impedance source to currents of almost the same value into a high impedance load.



(A)



(B)

Figure 3. Common Base Amplifier

Current in the emitter of either transistor splits between the base and the collector. The relation is the same as before.

$$I_c = B\, i_b$$

$$I_e = (B+1)\, i_b$$

Since the collector impedance is high, the load impedance can be high. Power out is equal to $I\ R_{out}$. Emitter impedance is low (approximately 1 Ω ÷ [B+1]). Power in is equal to $I_e^2\, R_{in}$.

3-14. Power Gain G_p is:

$$G_p = \frac{I_c^2\, R_{out}}{I_e^2\, R_{in}}$$

$$= \frac{(Bi_b)^2\, R_{out}}{[(B+1)\, i_b]^2\, \frac{1\ k\Omega}{(B+1)}}$$

$$= \frac{(B+1)(Bi_b)^2\, R_{out}}{(B+1)^2\, i_b^2 \cdot 1\ k\Omega}$$

$$= \frac{B^2\, R_{out}}{(B+1)\ 1\ k\Omega}$$

Since B+1 is only slightly larger than B, assuming B = 50 or more, which is common,

$$G_p \approx \frac{R_{out} \cdot B}{1\ k\Omega}$$

Since the collector impedance is generally from 20 kΩ to 100 kΩ,

$$G_p \approx \frac{60\ k\Omega \cdot B}{1\ k\Omega} = 3{,}000 = 35\ dB$$

Usual power gain is 10 dB to 20 dB. This circuit is usually used to obtain higher frequency response in an amplifier. It will be called a common base amplifier.

3-15. TWO-STAGE AMPLIFIERS.

3-16. The circuits described in this section contain two stages of amplification, using the circuits described in Section 2. Circuits may be direct coupled, capacitor coupled, or transformer coupled.

3-17. The circuit in Figure 4 has in it two common emitter circuits, capacitor coupled.

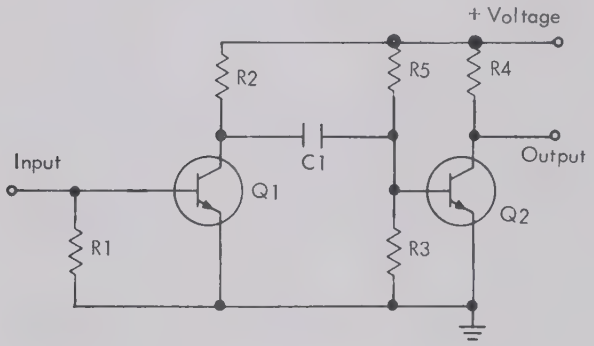


Figure 4. Two-Stage Capacitor-Coupled Amplifier

Resistor R5 is added to provide bias to Q2 so that Q2 will not normally be cut off. R3 is often not used in the circuit, since it puts additional load on the output of Q1.

3-18. Another bias variation connects the top of R5 to the output rather than to + voltage. Since output voltage changes are of opposite polarity to input voltage changes, this is a negative feedback path which tends to maintain constant collector current in Q2. This gives automatic bias correction for changes in supply voltage and in temperature. Input impedance to Q2 is lowered, which reduces overall gain, generally by about 3 dB. Capacitor C1 disconnects the direct voltage of the Q1 collector from the base of Q2 so that the biasing described above may be achieved. This circuit will be called a two-stage capacitor coupled cascade amplifier.

3-19. The circuit, as shown, has a power gain, usually, of 40 dB to 60 dB. The loss of gain below twice that shown for each simple amplifier is due to the low impedance (1 kΩ) load presented to the collector of Q1 by the base of Q2.

3-20. The circuit in Figure 5 uses one PNP (Q1) and one NPN (Q2) transistor in a two-stage direct coupled amplifier.

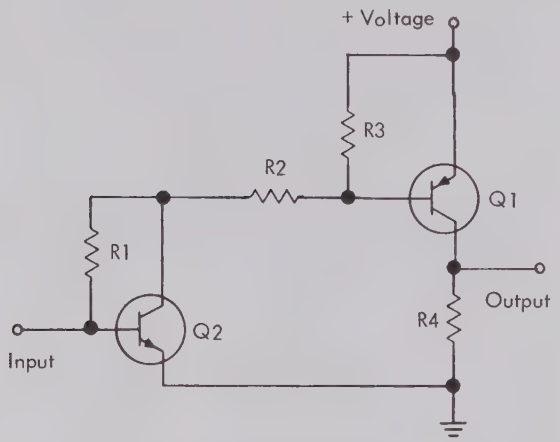


Figure 5. Two-Stage Direct-Coupled Amplifier

The input current varies the current to the base of Q2. Current is normally supplied through R1, which maintains a constant current in the collector of Q2. This feedback current, however, is not sufficient to cancel the effect of the input current. For this automatic bias circuit, the collector current change is about 70% of what it would be if fixed bias was provided. R2 provides voltage changes at the collector of Q2 so that automatic bias in R3 bypasses part of the collector current from Q2 so that it does not go to the base of Q1. Since current into the base of Q1 varies as the square of the voltage across R3, R3 can be selected so that more than half the collector current of Q2 flows through R3, but more than 70% of the changes in the collector current of Q2 occur in the base current of Q1.

3-21. Changes in the collector current of Q1 are equal to B times changes in base current. The current gain through the whole circuit:

$$G_I \approx B_2 \cdot 0.7 \cdot 0.7 \cdot B_1$$

$$= 0.5\, B_1 B_2$$

Input impedance to Q2 is about 800Ω, considering effect of feedback. Assuming a 1 kΩ load, R4 power gain is:

$$G_p = (0.5\, B_1 B_2)^2 \frac{1\,k\Omega}{800\,k\Omega} =$$

For $B_1 = B_2 = 60$,

$$G_p = (0.5 \cdot 60 \cdot 60)^2\, 25 = 4{,}050{,}000 = 66\ dB$$

This is a common figure for the power gain of this type of circuit. This circuit will be called a complementary two-stage amplifier.

3-22. The circuit shown in Figure 6 uses two NPN transistors in common emitter configuration, transformer coupled. DC bias for Q1 is provided by R1 and R2. R5 determines the emitter-current flow for the voltage set by R1 and R2. Direct collector current is usually set at one-half the desired peak current. R3 and R4 provide bias for Q2. R6 determines emitter current flow for Q2. Capacitors C2 and C3 bypass

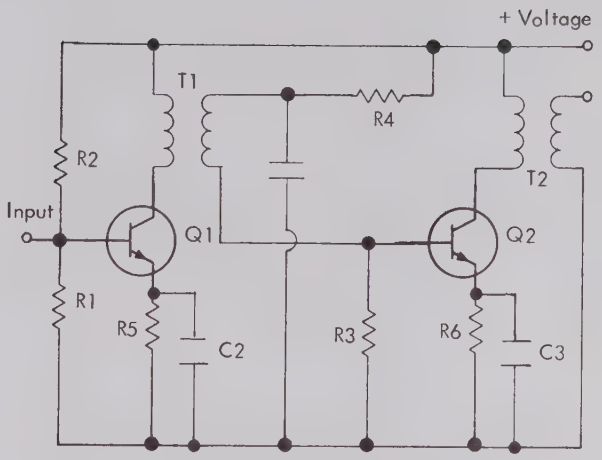


Figure 6. Two-Stage Transformer-Coupled Amplifier

around the emitter resistors so that input impedance (ac) to the transistors is low, hence low power is needed to provide the proper signal current into each base. In each transistor, input signal current times B is equal to collector signal current.

3-23. The transformer, T1, matches impedance of the collector of Q1 (around 16 kΩ) to the impedance of the base of Q2 (around 1 kΩ). This makes signals current into the base of Q2 four times the collector signal current in Q1. C1 bypasses transformer current to ground so that the load on the transformer is actually 1 kΩ, rather than 1 kΩ plus R4, which is what it would be without C1.

3-24. From the preceding discussion it is seen that current in the primary of T2 will be:

$$I_{T2} = I_{input}\, B_1 \cdot 4 \cdot B_2$$

For $B_1 = B_2 = 60$,

Current Gain $G_I = 60 \cdot 4 \cdot 60 = 14{,}400$

Assuming 1 kΩ input impedance and 16K impedance at the T2 primary, Power Gain:

$$= G_I^2 \cdot \frac{Z_{out}}{Z_{in}}$$

$$= 14{,}400^2 \ \frac{16\,K}{1\,K}$$

$$G_p = 207{,}360{,}000 \times 16 = 3{,}717{,}760{,}000$$

$$\approx 96\ dB$$

The secondary of T2 is to be connected to the load. The turns ratio of T2 is to be the ratio required for exact impedance match. It will be seen that insertion of transformers increases the gain of the two-stage complementary amplifier by 30 dB. This is done at the expense of inserting a number of biasing resistors and bypass capacitors, and of eliminating direct current amplification.

NOTE

Descriptions of multi-transistor amplifiers will be in the general form: For example, "Three-stage, capacitor coupled, plus complementary two-stage, plus emitter follower, amplifier." This means 3 stages of Figure 1A (or B), capacitor coupled as in Figure 4, followed by the circuit of Figure 2A (or B).

3-25. INTEGRATED CIRCUITS.

3-26. Several types of integrated circuits are used. They will be treated as single active parts having one or more inputs and one or more outputs. For signal tracing purposes, power supply connections will be ignored except where they are used as signal outputs. These applications will be described in detail in the Circuit Theory text.

3-27. OPERATIONAL AMPLIFIERS.

a. Operational amplifiers are direct-coupled multi-transistor amplifiers. They have differential inputs and either single or differential output current and/or voltage gain is usually from 1,000 to 100,000. Power gain is not especially high because input impedance is usually very high (1 MΩ or more), and output impedance is rather low (about 500 Ω). Assuming:

current gain = G_I = 100,000

input impedances = Z_{in} = 1 MΩ

output impedance = Z_{out} = 500 Ω

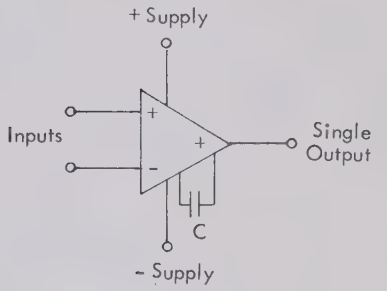
$$\text{Power Gain} = G_p = G_I^2 \frac{Z_{out}}{Z_{in}}$$

$$= (10^5)^2 \frac{500\,\Omega}{10^6\,\Omega}$$

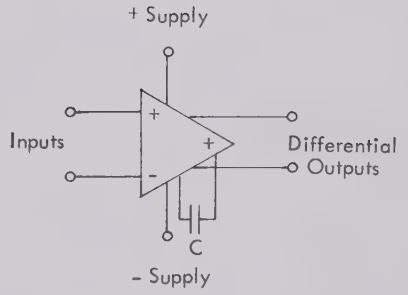
$$G_p = 5 \cdot 10^6 = 67\ \text{dB}$$

This is similar to the gain of a two-stage complementary amplifier.

3-28. The characteristics which lead to the use of IC operational amplifiers are very high impedance inputs, high rejection of effect of common mode inputs (both differential inputs move in the same direction, over many volts, while the differential voltage only moves a few millivolts), and low phase shift through the circuits so that negative feedback can be used readily without causing oscillations. The symbols used are shown in Figure 7, A and B. In Figure 7A and B, capacitor C is a frequency compensation capacitor, usually having a value of 10 to 100 pF. This capacitor reduces probability of oscillation. If the voltage on the input marked + is more positive than the voltage on the input marked –, output voltage from the terminal marked + is positive with respect to the center point of + supply and - supply voltages. A negative voltage on + input (in the terms used previously) gives a negative output voltage. The output terminal marked - has opposite polarity to that of the + output terminal. From the aforementioned, it will be seen that a positive voltage on - input will give a negative voltage on + output, and vice versa.



(A)

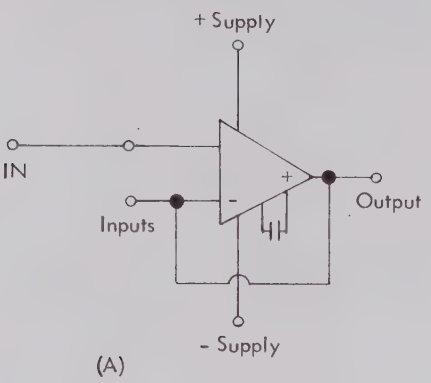


(B)

Figure 7. Operational Amplifiers

3-29. Operational amplifiers are often used as unity gain amplifiers with very low output impedance. Figure 8A and B show non-inverting and inverting unity gain amplifiers. In Figure 8A, +1 volts above ground (center between + supply and - supply) will drive the output positive. When the output is within a few microvolts of IN, the differential input is only a few microvolts, but this is sufficient to hold the output to +1 volt. The difference between input (IN) and output is approximately IN voltage divided by 100,000 (Gain).

3-30. In Figure 8B, +1 volts above ground (center between + supply and - supply) will drive the output negative. If the resistance of R1 is exactly equal to the resistance of R2, the potential at the minus input will be zero when output voltage is -1 volts. For output to be -1 volts, - input must be +1 volts divided by 100,000. Output voltage is of opposite polarity to input. The difference between output voltage magnitude and IN voltage magnitude is approximately IN voltage divided by 50,000.



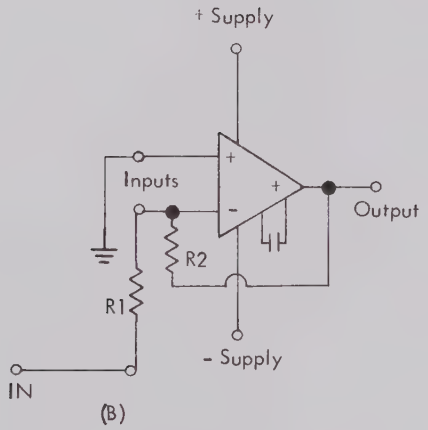


Figure 8. Unity Gain Operational Amplifiers

3-31. Operational amplifiers are often used as high gain linear amplifiers. In Figure 8B, if the resistance of R2 is 100 times the resistance of R1, the output voltage will be approximately 100 times IN voltage but of opposite polarity. This makes - input zero. For unity gain, here is a drop of one part in 50,000 in the output voltage so that - input voltage will have the valued required to produce the output voltage. This circuit cancels noise due to supply voltage variations; hence it is often used where high fidelity amplification is required.

3-32. Operational amplifiers are used as integrators. A typical simple circuit is shown in Figure 9. A positive voltage at IN will cause current to flow in R. This raises the voltage at the - input, so the output voltage goes negative, which, via C2, holds the - input voltage at approximately zero. Current through R must, effectively, flow into C2, hence it must also flow out of C2, into the amplifier output. This means that the voltage across C2 increases with time. Since - input voltage is very near ground potential and very near constant, in terms of the voltages usually applied at IN, the current through R is directly proportional to voltage at IN. The voltage across C2 is the exact time integral of the voltage at IN.

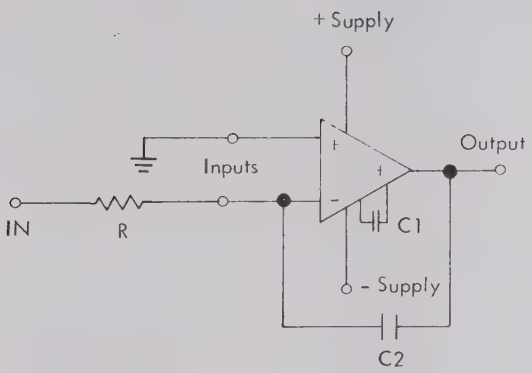


Figure 9. Integrating Operational Amplifiers

3-33. This circuit is used to produce the integral of a varying voltage, but it is usually used to produce voltage ramps which are linear with time. If the voltage at IN is constant, the output voltage is a linear voltage ramp until a limit of output voltage is reached.

3-34. Operational amplifiers are used as limit detectors (Figure 10). A differential input of a few microvolts will cause the output voltage of the amplifier to go to one limit. A similar magnitude of differential input, of opposite polarity, will cause the output voltage to go to the opposite limit. If a reference voltage is applied to one input, and an unknown voltage is applied to the other input, the output voltage will show polarity of voltage differences less than 1 millivolt. If the reference is equal to a limit voltage, the output changes polarity as the unknown voltage reaches and passes the limit voltage. This circuit is often used to control linear voltage ramps.

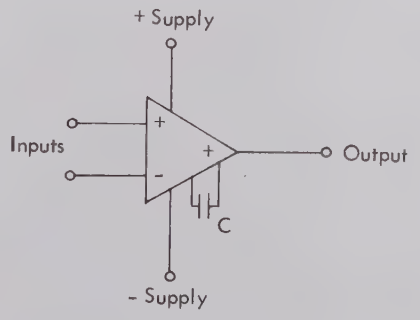


Figure 10. Limit Detector Operational Amplifiers

3-35. LOGIC CIRCUITS.

3-36. The basic logic circuits are AND and OR gates. Symbols are shown in Figure 11. Logic circuits of all kinds usually operate from +5 volt supplies. Power connections are seldom shown in schematic diagrams. Actual signal voltages may vary in magnitude, but the standard signal voltage convention is: Plus 5 Volts is called High (H) or One (1); Zero Volts is called Low (L) or Zero (0). For the symbols shown in Figure 3-14: If both A and B of the AND Gate are 1, output C is 1. If either A or B of the AND Gate is 0, C is 0. If either A or B of the OR Gate is 1, C is 1. If both A and B of the OR Gate are 0, C is 0.

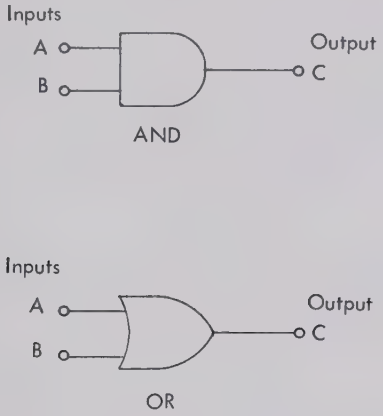


Figure 11. Logic Gate Symbols

3-37. Figure 12 shows another symbol. A small circle at any signal terminal of a gate reverses the meaning of any signal through the circle. NAND means "Not AND". For A and B both = 1, C is 0 ("Not 1"). NOR means "Not OR". For either A or B = 1, C is 0 ("Not 1"). In the Hybrid OR gate, 0 at A will give 0 at C. 1 at B will give 0 at C. Zero at B and 1 at A will give 1 at C.

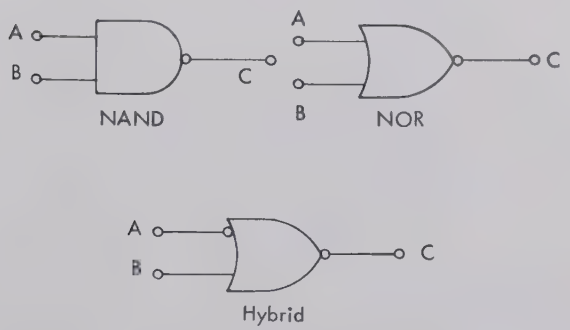


Figure 12. Gate Inversion Symbols

3-38. Another circuit in common use is the flipflop. This is also called a bistable multivibrator. Figure 13 shows the standard symbol. As with gates, flipflops generally use a +5 volt supply, which is not shown on most schematics.

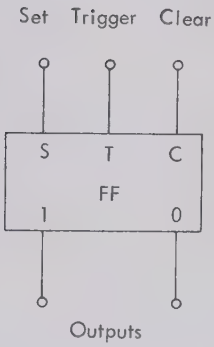


Figure 13. Flipflop

3-39. The flipflop is a two-state device. If Output 1 is 0, Output 0 is 1. If Output 0 is 0, Output 1 is 1. If there are no signal inputs, the flipflop will maintain its state. A 1 into Set (S) will cause a 1 at Output 1, regardless of past state. A 1 into Clear (C) will cause a 0 at Output 1 (hence a 1 at Output 0) regardless of past state. A 1 pulse into Trigger (T) will reverse the state of the flipflop. The reversal occurs at the leading edge of the pulse. A long pulse (over 5 milliseconds, usually) may cause indeterminate output for some flipflops. Others ignore everything but the positive-going leading edge.

3-40. Flipflops are used to store logic information in a circuit. This can be contrasted with the immediate transfer of information by amplifiers and by gates.

3-41. Two circuits of limited use are the other two multivibrators. They are the: (1) free-running MV or oscillator, and (2) monostable MV or one-shot. The free-running MV produces an alternating voltage of approximately square wave form. The one-shot reacts to an incoming 1 pulse by producing a 1 output pulse at a constant time thereafter. Timing of the delay may vary from a fraction of a microsecond to many seconds, or even a few minutes. Usual times are in the millisecond to second range.

SECTION IV
MAINTENANCE

4-1. GENERAL.

4-2. The Model 6610ED through 6616ED Plug-in Units are only used when they are plugged into a Model 6600(A) Main Frame. The environmental conditions for operation are the same as for the 6600(A). Storage temperatures should not exceed 75°C, as is typical for electronic gear. If there is long time storage at or above this temperature, the performance standards test procedure should be completed before the Plug-in Unit is put back into use.

4-3. TROUBLESHOOTING.

4-4. Troubleshooting procedures are described in Table 4-1. They are arranged by circuit functions. To locate the source of trouble for a function which is out of specification, find the function in Table 4-1. The indicated step will describe the proper method to find a faulty part. An adjustment procedure for the 6610ED follows the Troubleshooting Procedures. If adjustments may be required after replacement of parts, the proper step in the Adjustment Procedure is given.

NOTE

The RF Assembly, A2, is not considered field repairable. The entire Plug-in unit should be returned to factory if trouble is traced to A2. However, some indications of tracing signals within A2 are given in the Troubleshooting Table.

4-5. Troubleshooting steps identify related assemblies, **A** , Figures, [4-9.] , and paragraphs 4-45 by the types of numbers shown here. Figures are identified, in their lower right corners, by similar numbers.

4-6. Prior to following steps in Table 4-1, it should be determined that the 6600(A) has proper power applied, that test equipment is available, and that the plug-in is seated firmly in its socket in the 6600(A) or in the extender plug-in adapter.

NOTE

Connections between the functional schematics are shown by references to schematics [4-10.] to which adjacent terminals are connected. Connections between the circuits are shown by connector and pin numbers to which the signal lines are connected. Where connector numbers are prefaced by an assembly number, A2P1-2, the connector is on the indicated board. Where no assembly number is prefixed, P1-2, the connector is on the same assembly as the circuit parts in the schematics.

4-7. COMPONENT LOCATIONS.

4-8. The locations of assemblies within the Plug-in are illustrated in Figure 4-1 through 4-3. The locations of printed circuit boards and test points are shown.

4-9. PARTS LOCATIONS.

4-10. Locations of individual parts are shown with each schematic.

4-11. DETAIL CIRCUIT DESCRIPTIONS.

4-12. Individual Functional circuits are described in detail in connection with schematics which immediately follow the descriptions. General troubleshooting is best conducted by following signals paths through the circuits, as shown on the schematics. Primary Signal Flow is shown by heavy lines, with arrowheads. Secondary signals are shown by medium lines, with arrowheads. Feedback signals are shown by dash lines, with arrowheads. Arrowheads indicate direction of signal flow, without regard to polarity.

4-13. SAMPLE INVERTER, MASTER BOARD. **A1** FIGURE [4-4.]

4-14. The Sample Inverting Amplifier, U3, supplies to the Power Level Amplifier a negative voltage that is proportional to RF Power Out. Inputs to the sample inverter may be either positive or negative voltages from an external RF sample detector or a negative voltage from the internal RF sample detector.

4-15. The negative sample is applied at terminal 3 of the amplifier, the positive being applied at terminal 2, the inverting terminal of the amplifier. The output from terminal 6 is a negative voltage proportional to the input voltage. Diodes CR5 and CR6 limit the amount of voltage which can be fed out of this circuit, so that the amplifier U5 in the power level amplifier will not be damaged if by any chance excess voltage is applied to the input, allowing plus or minus 20 volts to appear at terminal 6 of U3.

4-16. POWER LEVEL AMPLIFIER, MASTER BOARD. **A1** FIGURE [4-5.]

4-17. The Power Level Amplifier provides the drive current for the PIN diode attenuator which is used to level the output of the RF oscillator. The principal input is a detected sample of the RF output. This signal is approximately 100 mV negative. It is fed into amplifier U5 which is a unity gain non-inverting amplifier, thence through an FET current control, Q20. Blanking, internal amplitude modulation and markers are applied at this point. These will be discussed in the description of the modulation amplifier. Output of Q20 is fed to amplifier U4.

4-18. Q20, with no bias, is ON, and the voltage on C16 is controlled by the low impedance output of U5. This non-inverting input to U4 is compared with the inverting input voltage from the voltage divider R83 and R84.

4-19. The input to R83, from the leveling half R3A of the level control dual potentiometer, is between ground and approximately +1.2 volts. The junction of R83 and R84 varies between -0.6 volts and +0.5 volts; normal voltage is zero to -0.2 volts. If the two inputs are exactly the same, the output of U5 is at ground potential. As the voltage on C16 goes negative, the output of U5 goes negative, with the feedback via R80, R81, and R82, output voltage is three times C16 voltages with a few hundred millivolts bias added by the forward drop across CR11.

4-20. Feedback via R79 and C19 reduce high frequency gain of the amplifier circuit. CR10 prevents output of U4 from being appreciably more positive than input 2.

TABLE 4-1. TROUBLESHOOTING PROCEDURES

Step No.	Symptom	Test Procedure	Result	Next Procedure	Assy No.	Fig. No.	Paragraph
1	Panel Lights Not Operating	1. Check fuse and power cord to 6600(A).	a. Open fuse.	a. Replace. **NOTE** Open fuses are usually caused by failure of other parts.	6600 (A)		
			b. Bad cord connection.	b. Correct.			
		2. Check power switch in 6600(A).	c. Fuse and cord OK	c. Go to step 2.			
		2. Check	a. Bad.	a. Replace			
			b. Good.	b. Check Transformer in 6600			
2	No RF Output	1. Check Fan operation in 6600(A).	a. Not Operating.	a. Check Fuse in 6600(A) and Line Cord	6600 (A)		
			b. Operating	b. Go to step 2.			
		2. Check control positions. Correct any errors in position.	a. RF present.	a. Return instrument to use.	Front Panel		
			b. No RF out.	b. Go to step 3.			
		3. Set for External Sample (-), with no input to Sample Jack.	a. RF present	a. Go to step 4.			
			b. No RF out.	b. Go to step 5.			
		4. Set for Internal Sample.	a. RF present.	a. Go to step 6.			
			b. No RF out.	b. Go to step 5.			
		5. Check Supply and Bias Voltages to Plug-in Unit (See Schematic)	a. All correct.	a. Go to step 8.	**A1**	6-1.	
			b. Supply Volts Low or zero.	b. Check 6600(A) power supplies.			
		6. Set for External Sample (+), with no input to sample jack.	a. RF present.	a. Go to step 7.			
			b. No RF out.	b. Check U3 of A1 for excess negative output to J1-2, with no input.			
		7. Connect to External Sample, positive voltage type	a. RF present.	a. Return Instrument to use.			
			b. No RF out.	b. Check external sample source for constant positive output.			
		8. Measure voltages into RF plate. Compare with voltages shown on schematics for RF plates (Figure 4-11 thru 4-14) Check E2 and/or E8, especially.	a. All voltages correct.	a. Go to step 9.	**A2**	4-11. thru 4-14.	
			b. E2 or E8 lower than shown on schematic.	b. Go to step 10.			
		9. Disconnect W3 from RF plate. Measure RF at output of RF plate.	a. No RF	a. Return RF plate to factory.			
			b. Full RF power.	b. Go to step 11.			

TABLE 4-1. TROUBLESHOOTING PROCEDURES (CONTINUED)

Step No.	Symptom	Test Procedure	Result	Next Procedure	Assy No.	Fig. No.	Paragraph
2 Cont.	No RF Output	10. Disconnect E2 and E8 connections. Measure voltage output from Plug-in without load.	a. Voltages are normal.	a. Return RF to Factory for repair or replacement.			
			b. Voltages low.	b. Check voltage sources back through Plug-in to 6600(A). Replace faulty part or correct control position.			
		11. Check operation of Attenuator, using another source of RF power.	a. Attenuator operates properly.	a. Check RF connection between YIG oscillator and attenuator. Replace coax cable, if needed.	A2	4-11. thru 4-14.	
			b. Attenuator does not pass RF.	b. Check input voltages and currents to attenuator; correct as needed. If voltages and currents are ok, and attenuator is still bad, return it to the factory for repair or replacement.			
3	Low RF Out	1. Check control positions. Correct any errors in position.	a. RF normal.	a. Return instrument to use.	Front Panel		
			b. Low RF out.	b. Go to step 2.			
		2. Set for External Sample (-), with no input to Sample Jack.	a. RF normal.	a. Go to step 3.			
			b. Low RF out.	b. Go to step 4.			
		3. Set for External Sample (+), with no input to sample Jack.	a. RF Normal.	a. Go to step 5.			
			b. Low RF out.	b. Check U3 of A1 for excess negative output with no input.	A1	4-4.	4-13.
		4. Check supply and bias voltages to Plug-in Unit.	a. All correct.	a. Go to step 8 of No RF Output.	A1	6-1.	
			b. Supply Volts Low or Zero	b. Check 6600(A) power supplies.			
		5. Connect to External Sample, positive voltage type.	a. RF present.	a. Return Instrument to use.			
			b. Low RF out.	b. Check external sample source for constant positive output.			
4	Output Not Leveled See Steps 1, 8, 9 of Table 4-2.	1. Check Leveling Switches. Set for Internal.	a. Leveling	a. Go to step 2.	Front Panel		
			b. Not Leveling	b. Go to step 3.			
		2. Set for External (+) or (-), as needed, with sampling input.	a. Leveling	a. Return Instrument to use.			
			b. Not Leveling	b. Go to step 5.			
		3. Check output of Leveling Amplifier.	a. Steady except for blanking.	a. Go to step 4.	A1	4-5.	4-16

TABLE 4-1. TROUBLESHOOTING PROCEDURES (CONTINUED)

Step No.	Symptom	Test Procedure	Result	Next Procedure	Assy No.	Fig. No.	Paragraph
4 Cont.	Output Not Leveled		b. Varies with RF output variation.	b. Go to step 6.			
		4. Vary input to Leveling Amplifier, using small current input.	a. Steady except for blanking.	a. Check Leveling Amplifier circuit.	A1	4-4.	4.13.
			b. Output level varies with input variation.	b. Go to step 6.			
		5. If External (-) is used, check for broken input connection; if External (+) is used, check for U3 of A1 out of order, then for broken input connection.					
		6. Check operation of Attenuator, using another source of RF power, disconnect W3 to make Attenuator input available.	a. Attenuator operates properly.	a. Check RF connection between YIG oscillator and Attenuator. Replace coax cable, if needed.	A2	4-11. thru 4-14.	
			b. Attenuator does not pass RF.	b. Check input voltages and currents to attenuator; correct as needed. If voltages and currents are ok, and attenuator is still bad return it to the factory for repair or replacement.			
5	No Amplitude Modulation from External Signal	1. Check operation of Attenuator, using another source of modulation. Disconnect W2 to make attenuator control input available, apply ± 1 volt square wave or sine wave.	a. Attenuator operates properly.	a. Check connection between AM connector and attenuator. Replace coax cable, if needed.			
			b. Attenuator does not modulate RF.	b. Return attenuator to factory for repair or replacement.			
6	Intermittent or Failed Blanking	1. Check blanking signal input.	a. Signal is good.	a. Go to step 2.	A1	4-7.	4.24
			b. Signal disappears.	b. Repair 6600(A).			
		2. Trace Blanking signal through Q14, Q13, R73, to Attenuator.	a. Signal disappears.	a. Replace part which caused disappearance.			
			b. Signal is proper at attenuator.	b. Return attenuator to factory for repair or replacement.			
7	No RF Markers	1. Check for presence of RF markers on Pin 21 of Plug-in Unit connector.	a. No markers.	a. Check control settings on 6600(A). Check 6600(A) marker generator.	A1	6-1.	4.24
			b. Markers present.	b. Trace marker signal through Q12 and Q13 of Amplitude Modulation circuits. Output to attenuator may be checked on AM external jack, J3.	A1 Rear Panel	4-7. 2-2.	4.24

TABLE 4-1. TROUBLESHOOTING PROCEDURES (CONTINUED)

Step No.	Symptom	Test Procedure	Result	Next Procedure	Assy No.	Fig. No.	Paragraph
8	Unwanted Amplitude Modulation, Noise or Ripple.	1. Check for noise on supply voltages from 6600(A).	a. No Noise.	a. Go to step 2.	A1	6-1.	
			b. Noise from 6600(A).	b. Repair 6600(A). See Manual for 6600(A)			
		2. Check for noise on output of Power Leveling Amplifier.	a. No Noise.	a. Check for poor connections, dirty contacts, between leveling amplifier output, J1-10, and pin drive input, J1-14. Go to step 4.	A1	4-5.	4.16
			b. Noise.	b. Go to step 3.			
		3. Check for noise on input of leveling amplifier, J1-8. Short input to stop noise at this point.	a. Noisy input.	a. Trace noise back from input.			
			b. No noise on input. Noise on output with input shorted.	b. Trace noise back stage by stage to source in Amplifier.			
		4. Check noise at input and output of Q17 and Q18 darlington circuit, in AM circuits.	a. No noise at output of Q17 and Q18.	a. Check connection to attenuator. Go to step 1 of no amplitude modulation from external signal.			
			b. Noise at output with no noise at input.	b. Check for noise via Q13. Trace back, if present. If Q13 is not source, replace Q17 and/or Q18, R73, R74.			
9	No Frequency Sweep. RF is present.	1. Check control positions on 6600(A).	a. All proper.	a. Go to step 2.	Front Panel		
			b. In Error.	b. Correct control positions.			
		2. Check F1, F2, F3, from 6600(A), into tuning voltage amplifier, P1-2, P1-24, P1-1.	a. Normal.	a. Go to step 3.	A1	4-8.	4.28
			b. Are not normal.	b. Check circuits in 6600(A).			
		3. Check for sweep at E5, of tuning voltage amplifier.	a. Sweep is present.	a. Go to step 4.			
			b. Sweep is not present.	b. Go to step 5.			
		4. Check for sweep at tuning and input of Y1G oscillator.	a. Sweep is present.	a. Return Y1G oscillator to factory for repair or replacement.	A2	4-11. thru 4-14.	
			b. Sweep is not present.	b. Find open connection between E5 and tuning and input of Y1G oscillator.			
		5. Trace signal path back through Q8, Q7, Q6.	a. Sweep found.	a. Replace last transistor which had no sweep at output.	A1	4-8.	4.28
			b. No sweep at output of U2.	b. Check relative bias on inputs 2 and 3. If less than 3 mV, replace U2. If more, look for bad resistor, R39, R38, R35, R34, R40.			

TABLE 4-1. TROUBLESHOOTING PROCEDURES (CONTINUED)

Step No.	Symptom	Test Procedure	Result	Next Procedure	Assy No.	Fig. No.	Paragraph
10	Frequency Offset from Dial Setting See Steps 3, 4, 5 of Table 4-2.	1. Check F1 (0 to +10V). Linear Sweep, for Full Band Sweep.	a. Voltage is offset.	a. Repair 6600(A).	A1	6-1.	
			b. Voltage normal.	b. Go to step 2.			
		2. Trace F1 sweep through tuning voltage amplifier. Check with figures on schematic.	a. Sweep position changes in circuit.	a. Replace parts which cause position change.			
			b. Output to Y1G oscillator is normal.	b. Return Y1G oscillator to factory, for repair or replacement.			
11	Erratic Frequency Sweep	1. Same as 2 for Step 9, No Frequency Sweep, plus possible dirty contacts in connectors.	Read erratic sweep for no sweep.				
		2. Check for noise on supply voltages.	a. Noisy	a. Correct in 6600(A)			
			b. Normal.	b. Expect problem to be in linear sweep voltages.			
12	FM Noise See Steps 3, 4, 5 of Table 4-2.	1. Look for bad connections in Linear Sweep lines.	a. Bad connections.	a. Clean contacts.	A1	4-8.	4.28
			b. Good connections.	b. Go to step 2.	A1	4-9.	4.30
		2. Look for noise on linear Sweep Voltage.	a. Noise on sweep.	a. Repair 6600(A).			
			b. Clean sweep.	b. Go to step 3.			
		3. Trace tuning voltage through tuning voltage amplifier.	a. Noise appears in TVA circuit.	a. Repair circuit. Replace noisy part.			
			b. Sweep is clean at input to Y1G oscillator.	b. Return Y1G oscillator to factory for repair or replacement.			
13	External FM Failure See Step 8 of Table 4-2.	1. Check for FM input to FM driver.	a. No input.	a. Correct FM supply from external source.	A1	4-9.	4.30
			b. Input present.	b. Go to step 2.			
		2. Check for output to E4.	a. No output.	a. Go to step 3.			
			b. Output.	b. Go to step 4.			
		3. Check continuity through oscillator from E4 to E3.	a. Continuity.	a. Trace signal through FM driver. Replace faulty part.			
			b. No continuity.	b. Return oscillator to factory for repair or replacement.			
		4. Check for short circuit or bypass of signal around oscillator.	a. By pass.	a. Correct circuit.			
			b. Signal goes through oscillator.	b. Return oscillator to factory for repair or replacement.			
14	Network Analyzer (NA) Adapter; VPF output not accurate. As on next page. See Steps 6, 7 of Table 4-2.	1. Determine accuracy of VPF output of 6600(A). Pin 23 of Plug-in connector. (0 to -10 V.	a. Inaccurate (non-linear) sweep.	a. Troubleshoot 6600(A) main frame for inaccurate VPF.	A1	4-10.	4.32
			b. Sweep is linear and starts at zero.	b. Adjust R12 (zero adjust) for zero volts ± 50 mV, out, of N.A. connector, at			

TABLE 4-1. TROUBLESHOOTING PROCEDURES (CONTINUED)

Step No.	Symptom	Test Procedure	Result	Next Procedure	Assy No.	Fig. No.	Paragraph
14 Cont.	Network Analyzer (N.A.) Adapter; VPF output not accurate.			lower end of full band. Adjust R14 (Max V adjust) for proper voltage ± 50 mV, out of N.A. connector at upper end of Full Band. Model — Full Band Voltage 6610ED +40.00 6611ED +40.00 6612ED +40.00 6615ED +22.00 6616ED +18.068 Repeat to overcome interaction between controls. If these voltages cannot be obtained, go to step 2.			
		2. Trace voltages through the N.A. Adapter circuit. Compare with voltages on schematic, for low frequency setting and for high frequency setting.		Replace part(s) which cause improper voltages in circuit.			

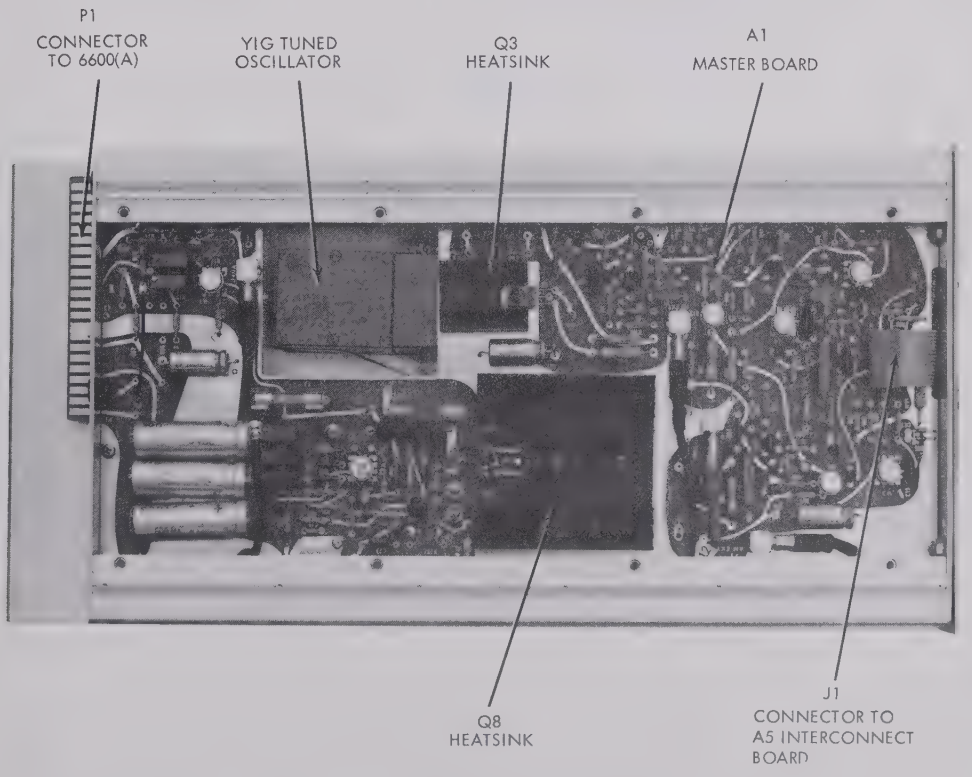


Figure 4-1. Top View of 6610ED Assembly Locations

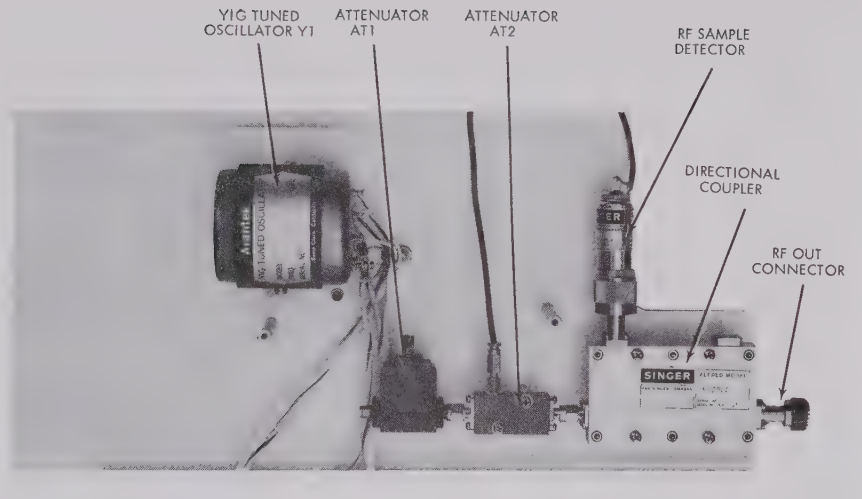


Figure 4-2. Top View of 6612ED Master Board Removed Assembly Locations

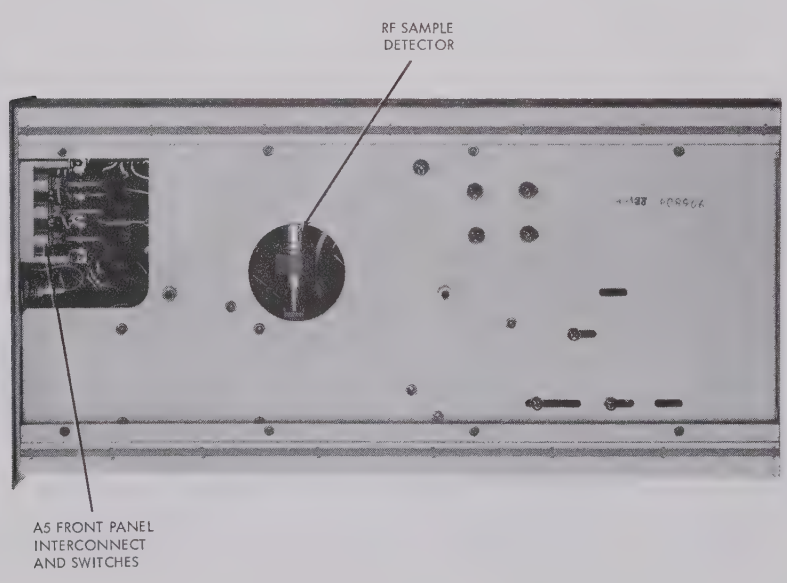
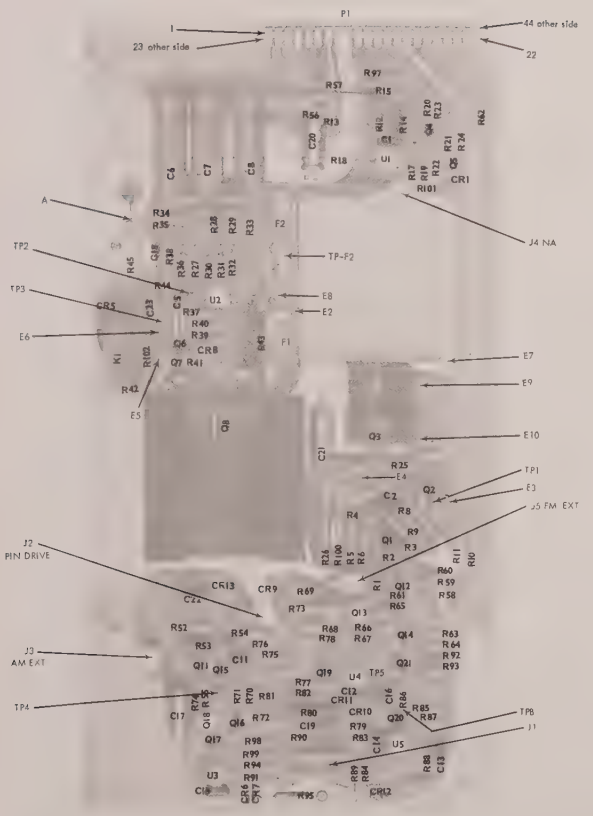
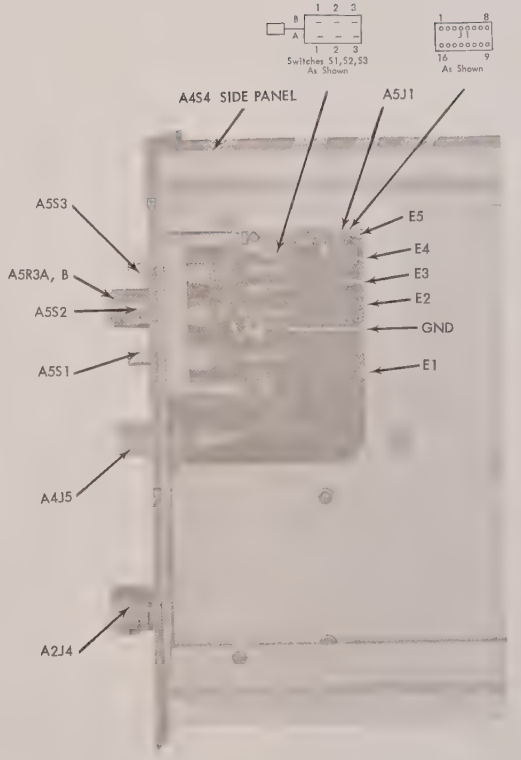


Figure 4-3. Bottom View of 6611ED Assembly Locations



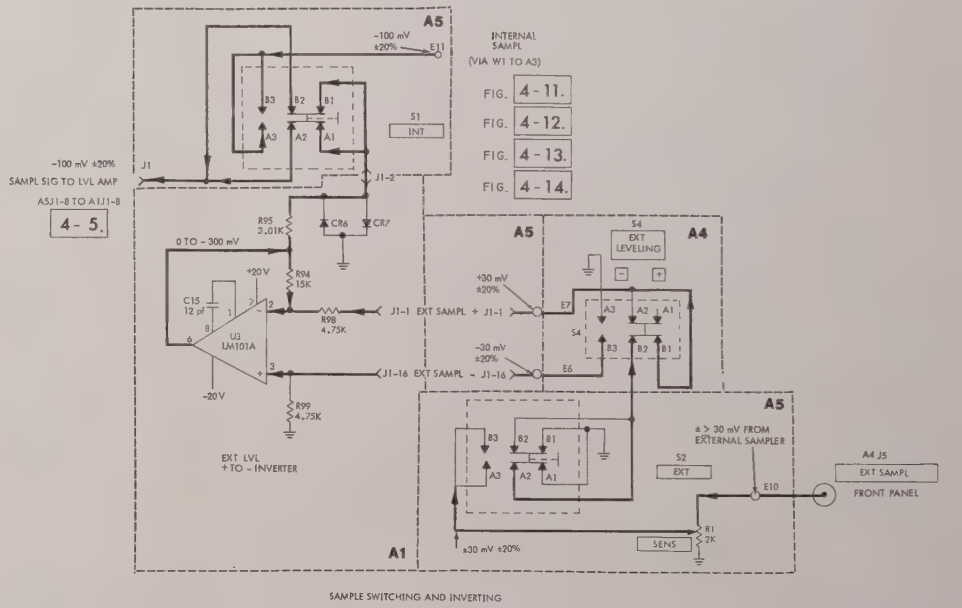
A1

Parts Locations



A4 A5

Parts Locations

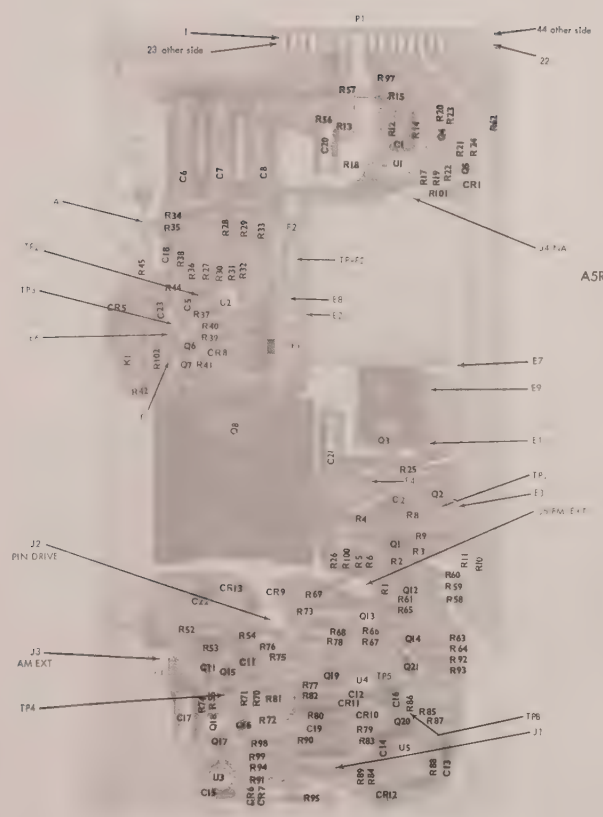


SAMPLE SWITCHING AND INVERTING

A4
A5
A1

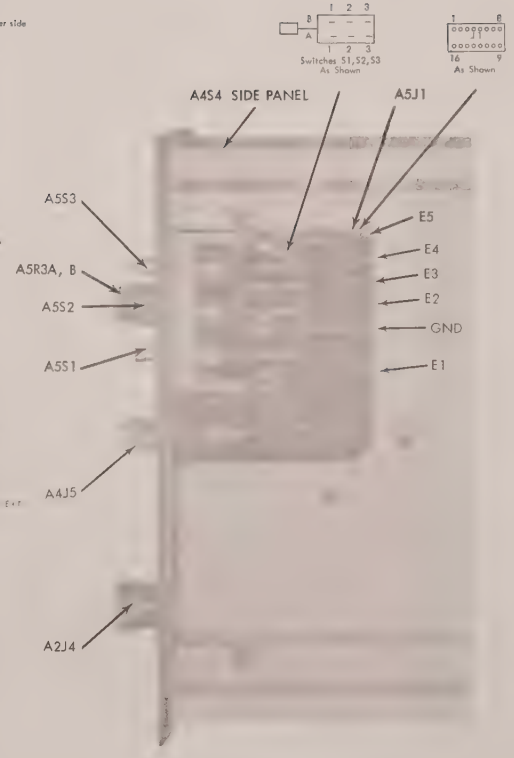
4-4.

Figure 4-4. Sample Switching and Inverting



A1

Parts Locations



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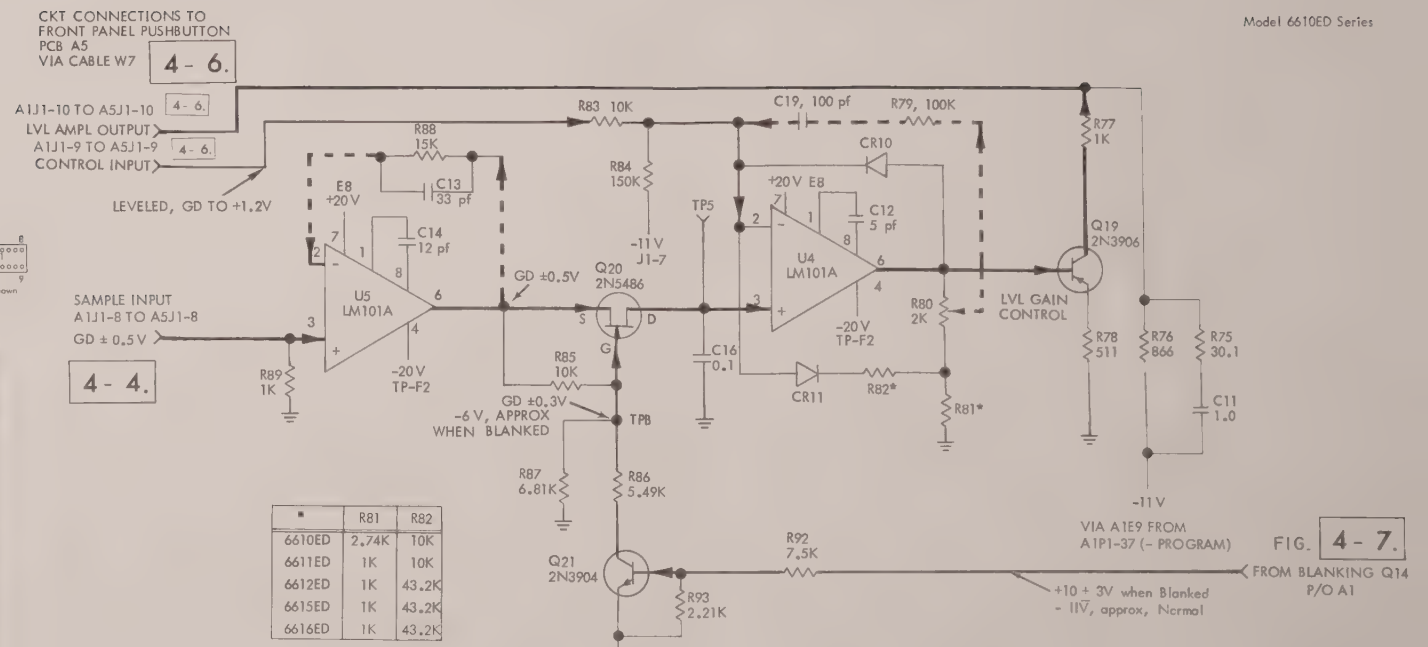


	R81	R82
6610ED	2.74K	10K
6611ED	1K	10K
6612ED	1K	43.2K
6615ED	1K	43.2K
6616ED	1K	43.2K

Figure 4-5. Leveling Amplifier **A1**

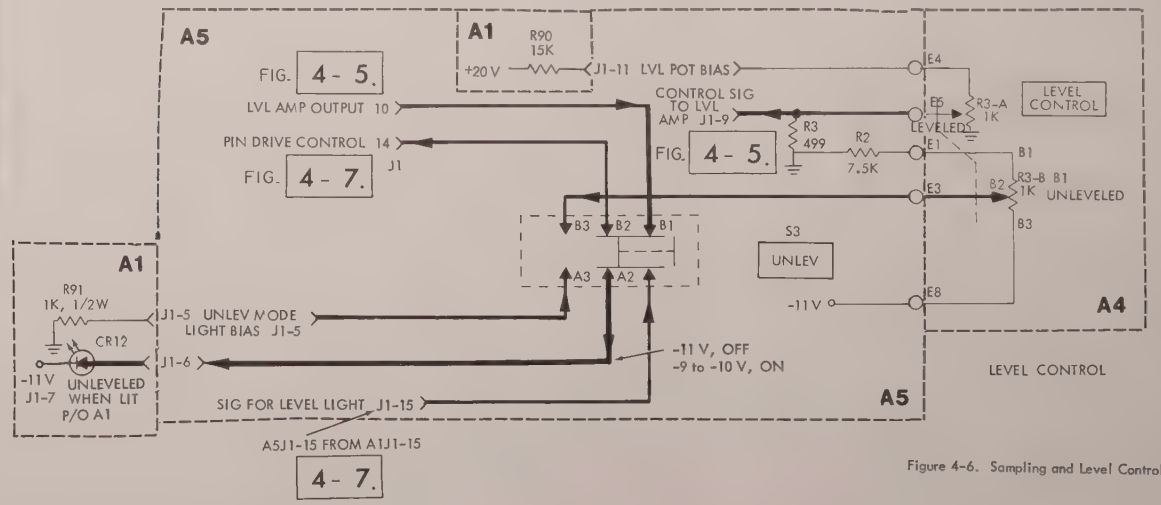


Figure 4-6. Sampling and Level Control Circuits

A4
A5
A1

4 - 5.

4 - 6.

4-21. The negative voltage at the base of Q19 causes current to flow in its collector. The output of Q19 then goes to a level control switch and when leveling is desired, it is fed back to the input of Q17 and Q18 which form a Darlington circuit in the modulation amplifier. The output of this Darlington circuit drives the PIN diodes directly, increasing attenuation of the pin diode circuit, hence reducing RF output. Thus leveling of the RF output is achieved.

4-22. When unleveled output is desired, switch S3 switches the input to Q17, of the Amplitude Modulation Circuit, from the leveling amplifier output to the unleveled half R3B of the level control dual potentiometer.

4-23. Variation of -9.5 volts to -10.5 volts from the potentiometer into the base of Q17 varies PIN diode current through R73 to control RF output level. Control via Q13 still occurs.

4-24. MODULATION AMPLIFIER, MASTER BOARD **A1** FIGURE 4-7.

4-25. External Amplitude Modulation is applied directly to the PIN drive via an external jack which is designated AM PIN. Internal AM is amplified by transistor Q14 and then by transistor Q13 which drives the PIN diodes via R73. Blanking input is in parallel with Internal AM. Markers are amplified by Q12, which drives Q13 via resistor R61. Q17 and Q18 drive the PIN diodes, via R73, to hold the output at the level set by the Leveling Amplifier via S3 of the Sample Switching and Inverting circuit. The drive from Q13 varies the attenuation by its parallel current drain from R73.

4-26. When Blanking signals occur, or when Internal Amplitude Modulation is applied, Q14 is driven by the inputs. In addition to driving Q13, Q14 drives Q21, which puts negative bias on Q20. This prevents current flow between U5 and C16, so C16 maintains its voltage at the level existing at the start of modulation. Only 0.3 μA bias current is required by input 3 of U4, so change in the voltage across C16 is negligible during normal blanking and modulation.

4-27. To indicate unleveled operation in Leveled Mode, an Unleveled when lit indicator is provided. Varying voltages at the collector of Q13 drive Q15. Q15 drives Q16 which in turn feeds current to the light emitting diode which indicates unleveled operation whenever there is a signal into Q15. Q11 provides the exact bias required by Q15 to have it respond to the exact size of signal which is the minimum signal for which the unleveled light should be illuminated. This allows presence of markers without illumination of the Unleveled When Lit light.

4-28. TUNING VOLTAGE AMPLIFIER, MASTER BOARD **A1** FIGURE 4-8.

4-29. The Tuning Voltage Amplifier supplies current for the magnetic field of the YIG tuned oscillator. Inputs to the amplifier are F1, F2, and F3 from the Main Frame, Model 6600, plus an adjustable bias from +10.5 volts. These four inputs are mixed at the inverting input to U2, a differential amplifier. The output of the differential amplifier is fed to Q6, a 0.2 gain inverter. Feedback from the output of Q6 goes to the non-inverting input of the differential amplifier to give a gain of approximately 125', however this gain goes down rapidly with frequency, the cut-off frequency being 8 Hz. The output of Q6 drives Q7, an emitter follower; which in turn drives Q8. The output from the collector of Q8 goes to the YIG tuned oscillator to provide the magnetic field around the resonant YIG crystal.

4-30. FREQUENCY MODULATION AMPLIFIER, MASTER BOARD **A1** FIGURE 4-9.

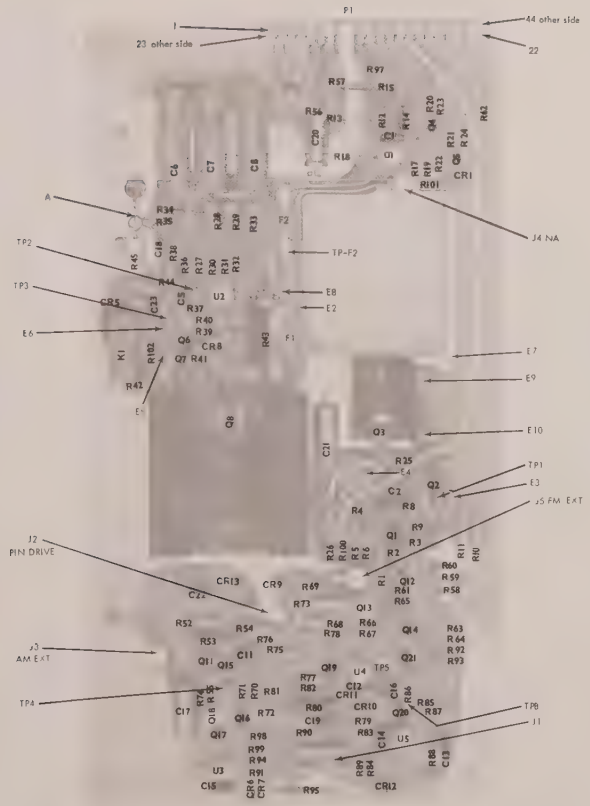
4-31. The Frequency Modulation Amplifier drives the magnetic field of the resonant YIG crystal to vary frequency when frequency modulation is applied to an external input. The circuit consists of a differential amplifier, Q1, which drives an emitter follower, Q2, which drives a common emitter amplifier, Q3. Feedback from the tuned oscillator is fed into the other input of the differential amplifier. The voltage drop across parallel resistors, R10 and R11, is almost equal to the voltage across R2, so current through the tuner is equal to 200 mA per volt across R2 or per 6 volts at J5.

4-32. NA ADAPTER CIRCUIT, **A1** FIGURE 4-10.

4-33. The Network Analyzer Adapter Circuit produces voltages proportional to frequency for each of the 6610ED Series Models. Tuning voltages are applied to the pin number 2 input of U1, which drives transistors Q4 and Q5 to supply an output to J2. Negative Feedback is applied to the input via R17. R12 adjusts the **minimum** frequency output to zero tages shown below.

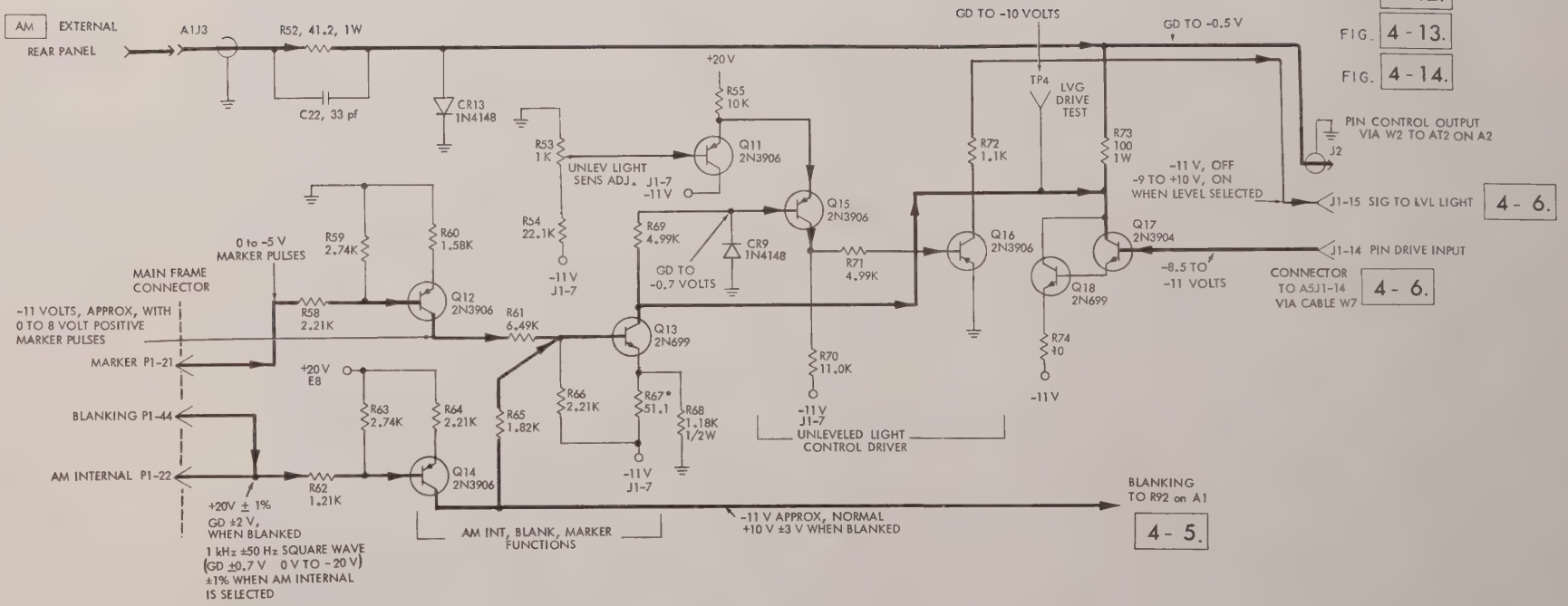
±0.1 V. R14 adjusts maximum frequency output to the voltages shown below.

Model Number	Maximum Frequency Voltage
6610ED	+40.0
6611ED	+40.0
6612ED	+40.0
6615ED	+22.00
6616ED	+18.068
	±1%



A1

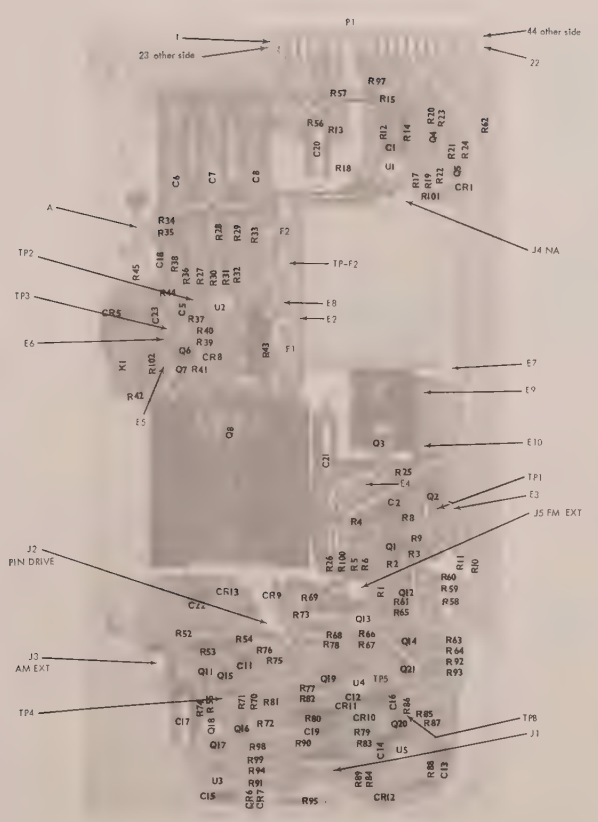
Parts Locations



A1

4 - 7.

Figure 4-7. Amplitude Modulation Circuits



A1

Parts Locations

NOTE:
UNLESS SPECIFIED OTHERWISE:

1. ALL RESISTORS IN OHMS 1/4W, 1%
2. ALL CAPACITORS IN MICROFARADS
3. ALL DIODES ARE 1N4148
4. *SEE TABLE FOR VALUE
5. NP NOT APPLICABLE
6. **INSTALLED ON CUSTOMER'S REQUEST FOR SPEC. MOD. CHARACTERISTICS
7. P1 PLUGS IN TO 6600 MAIN FRAME
8. ΔΔ FACT SEL - NOMINAL VALUE SHOWN

#	R34	R32	R33	R35	R36	R38	R39	R45	C6,7,8	F1	F2
6610ED	3.57K	9.31K	5K	442	442	442K	260	5	600 µf	OPEN	0.5 A
6611ED	3.48K	10K	2K	475	475	475K	374	2.4	600 µf	OPEN	1.0 A
6612ED	3.48K	10.5K	1K	499	499	499K	392	2.0	600 µf	0.5 A	1.5 A
6615ED	2.67K	4.99K	1K	475	475	475K	476	2.0	500 µf	1.0 A	1.5 A
6616ED	2.43K	4.12K	1K	536	536	499K	665	1.8	500 µf	1.0 A	2.0 A

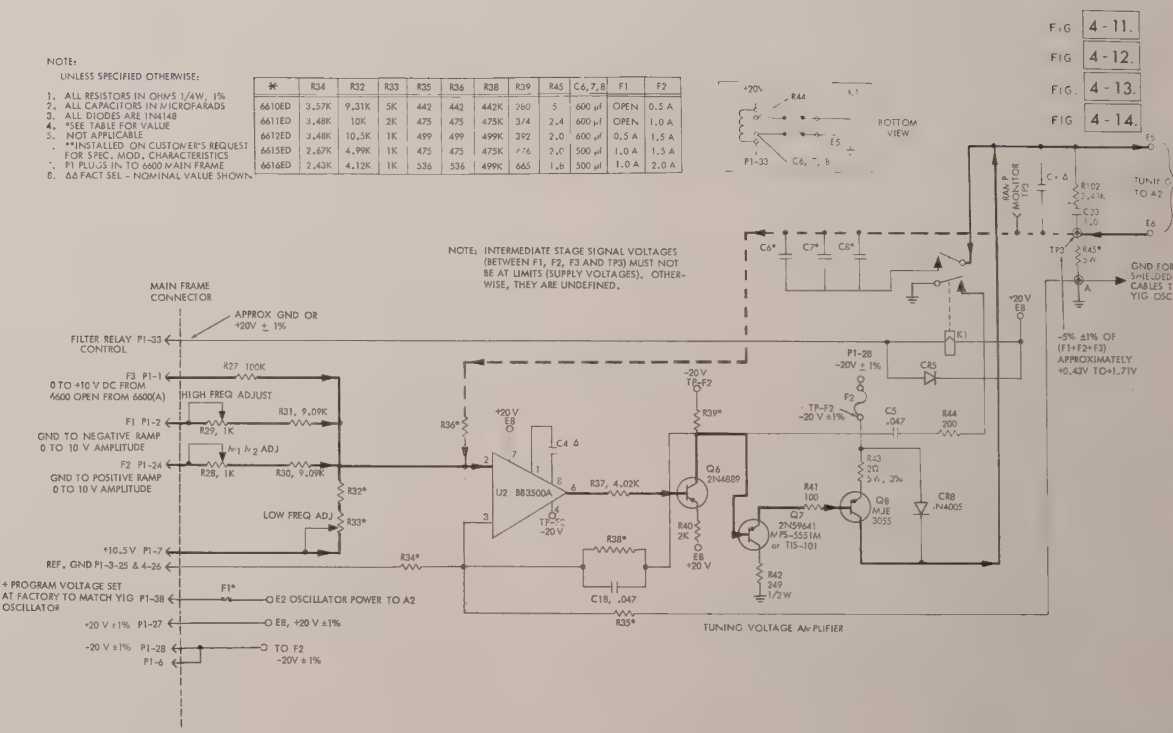
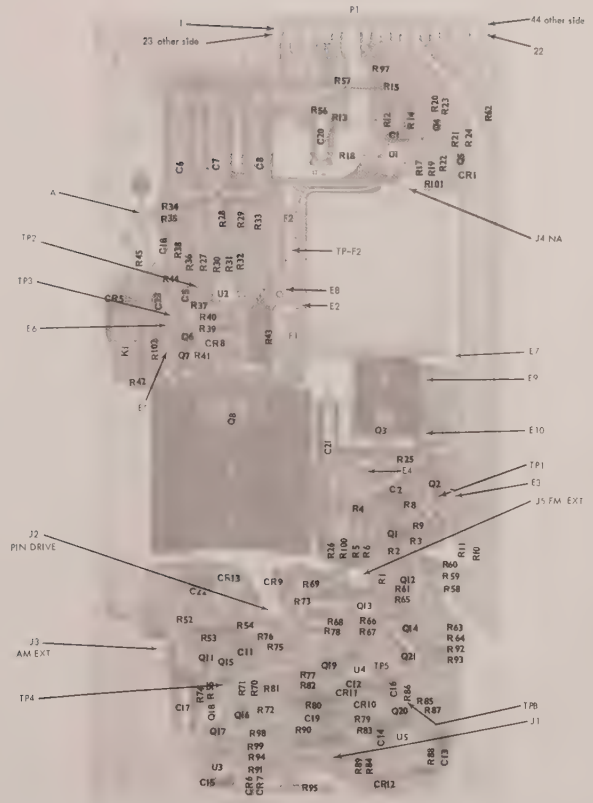


FIG 4 - 11.
FIG 4 - 12.
FIG. 4 - 13.
FIG 4 - 14.

A1

4 - 8.

Figure 4-8. Tuning Voltage Amplifier



A1

Parts Locations

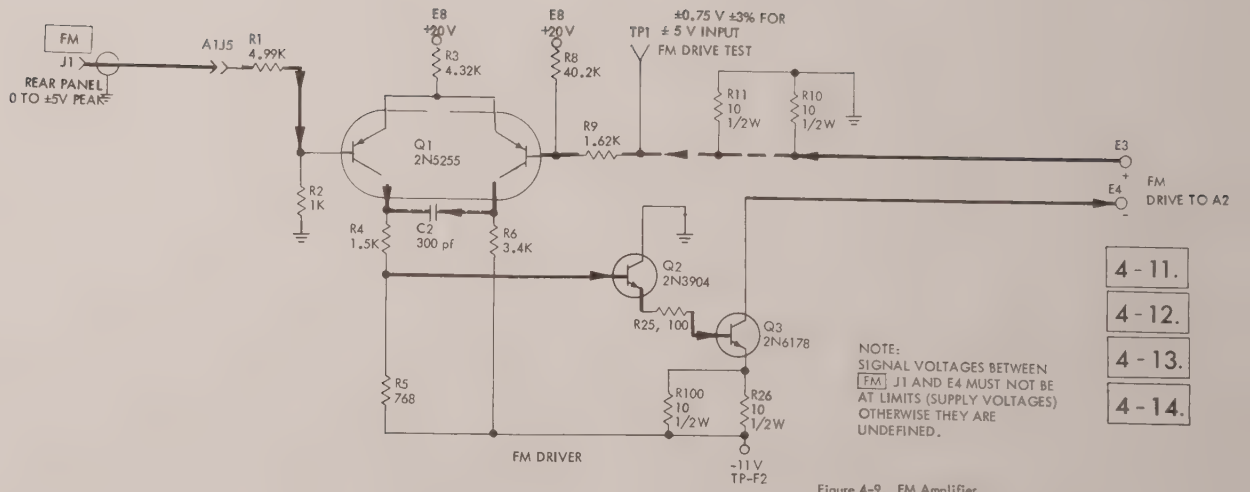
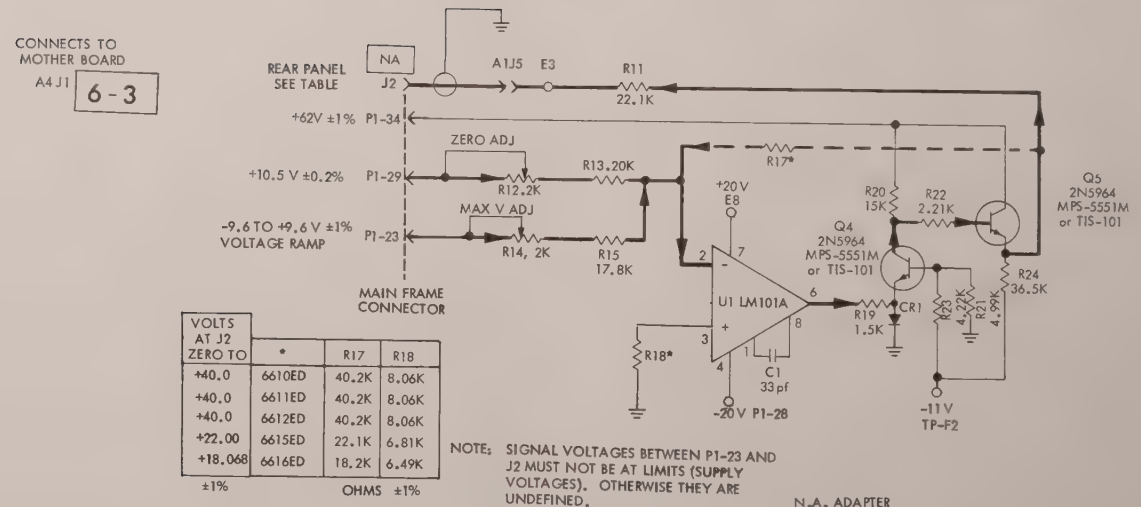


Figure 4-9. FM Amplifier



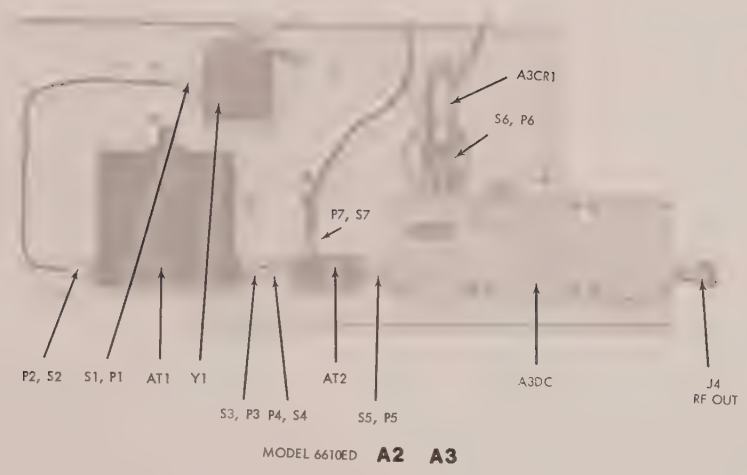
VOLTS AT J2 ZERO TO	*	R17	R18
+40.0	6610ED	40.2K	8.06K
+40.0	6611ED	40.2K	8.06K
+40.0	6612ED	40.2K	8.06K
+22.00	6615ED	22.1K	6.81K
+18.068	6616ED	18.2K	6.49K
±1%		OHMS	±1%

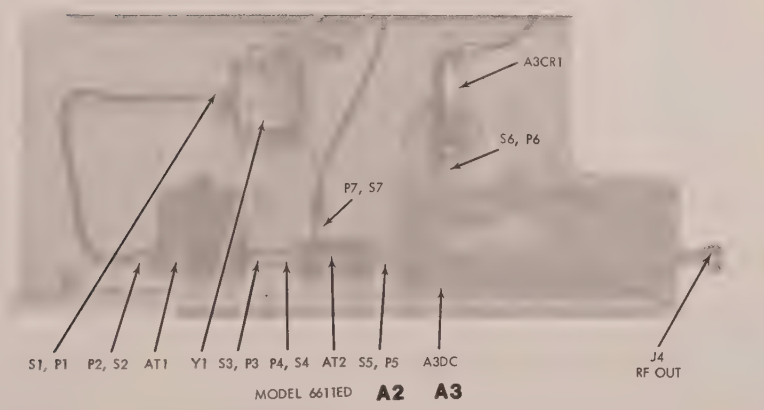
A1

4-9.

4-10.

Figure 4-10. NA Adapter Circuit





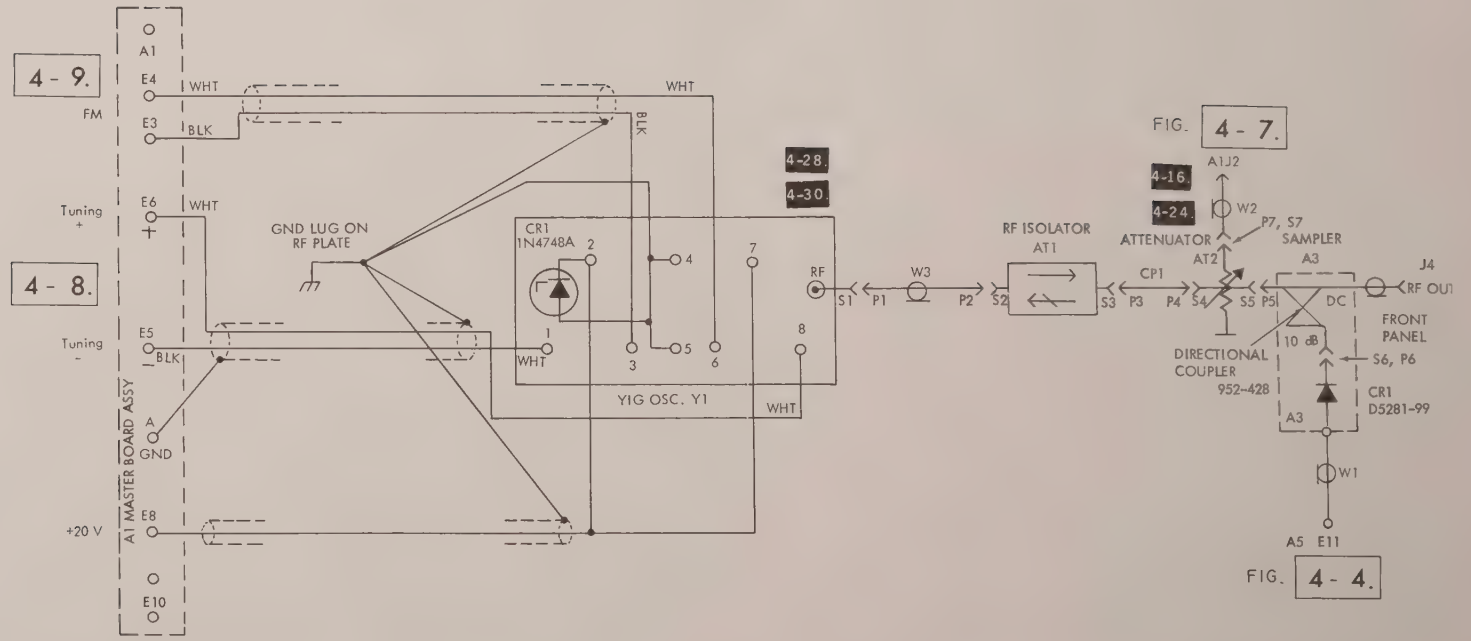
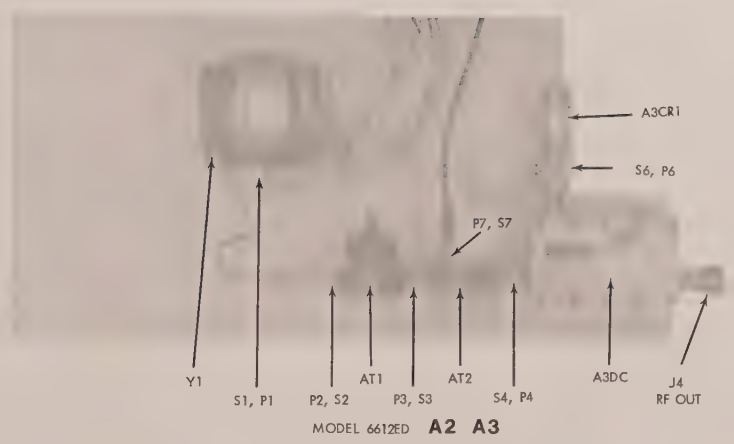
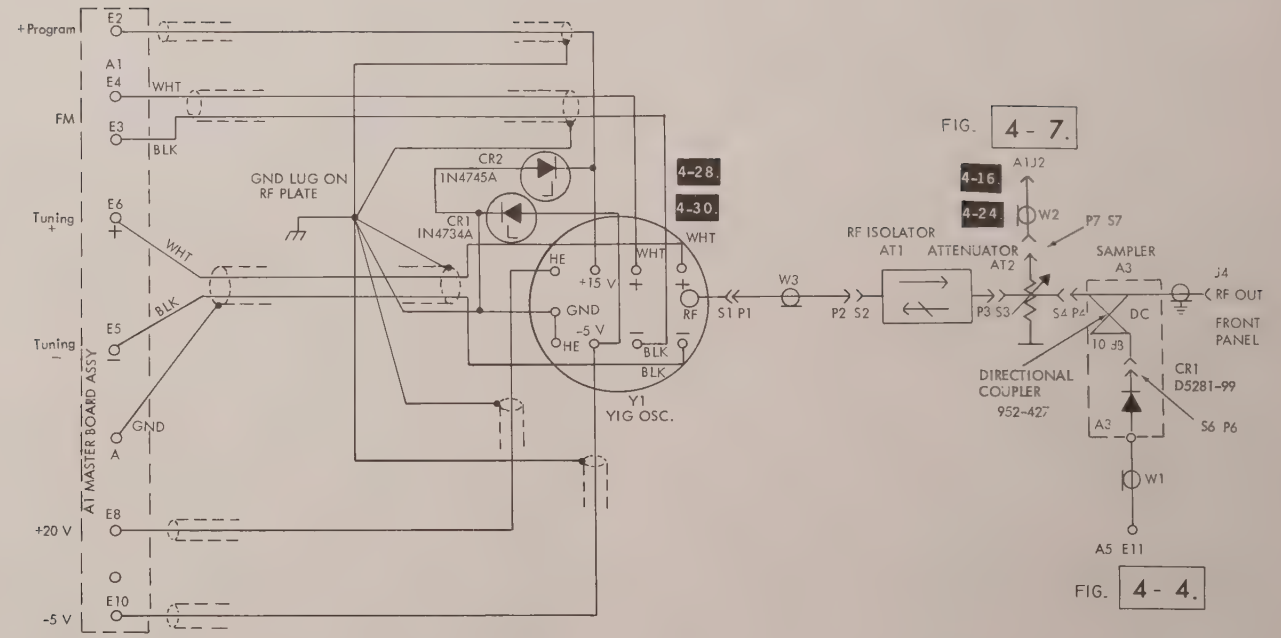


Figure 4-11. RF Plate Schematic Models 6610ED, 6611ED

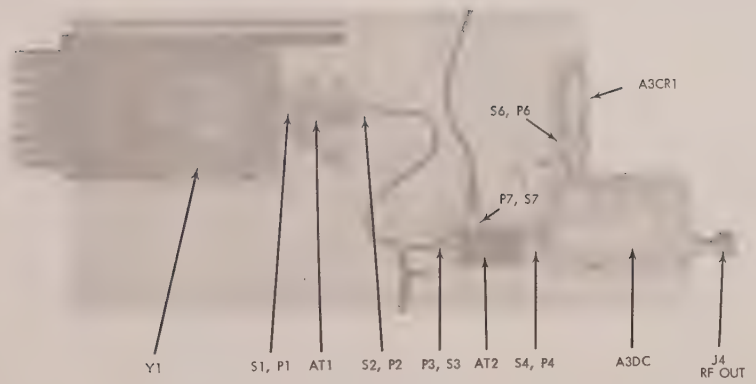




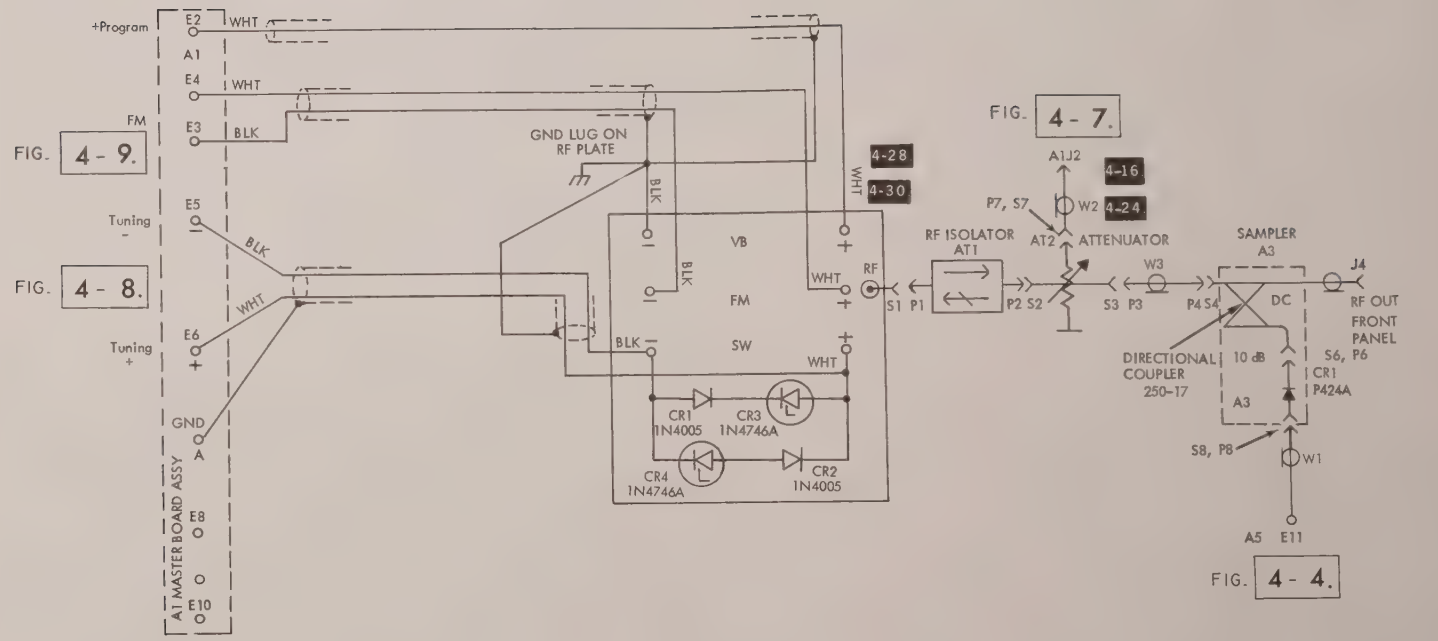
A2
A3

4 - 12.

Figure 4-12. RF Plate Schematic Model 6612ED



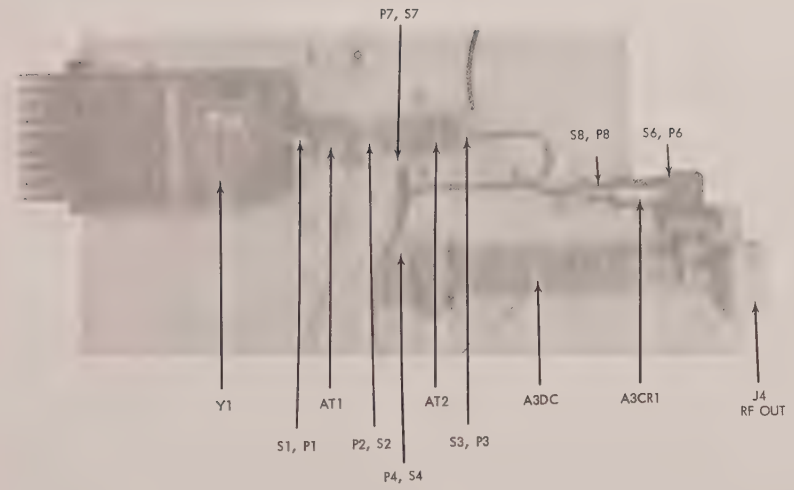
MODEL 6615ED **A2 A3**



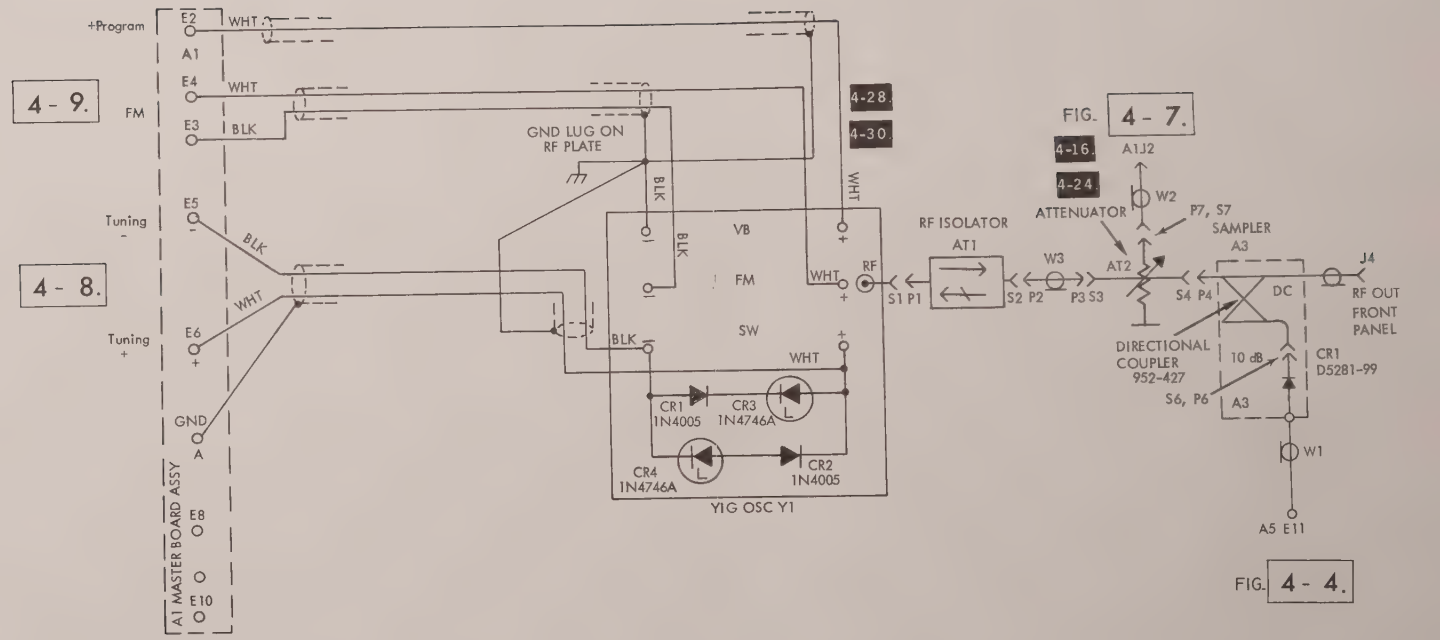
A2
A3

4 - 13.

Figure 4-13. RF Plate Schematic Model 6615ED



MODEL 6616ED **A2 A3**



A2
A3

4 - 14.

Figure 4-14. RF Plate Schematic Model 6616ED

4-34. ADJUSTMENT PROCEDURES.

4-35. There are ten adjustments possible in the Plug-in Unit. They are:

1. Level Gain - R80 in the Leveling Amplifier Figure 4-5.
2. Unlevel light Sensitivity - R53 in the Unlevel Light Amplifier, Figure 4-7.
3. Low Frequency Adjust - R33 in the Tuning Voltage Amplifier, Figure 4-8.
4. High Frequency Adjust - R29 in the Tuning Voltage Amplifier, Figure 4-8.
5. M1, M2 Adjust - R28 in the Tuning Voltage Amplifier, Figure 4-8.
6. VPF Zero Adjust - R12 in the NA Adapter (VPF Output), Figure 4-10.
7. VPF Max Adjust - R14 in the NA Adapter (VPF Output), Figure 4-10.
8. External Sample Sensitivity - R1 on Front Panel, Figure 4-4.
9. Level Control, Level Mode, R3-A on Front Panel, Figure 4-6.
10. Level Control, Unlevel Mode, R3B on Front Panel, Figure 4-6.

4-36. Adjust each of the controls listed above, as required, using the following procedures:

4-37. Remove Covers of Plug-in Unit.

4-38. Connect Plug-in Unit to the Model 6600(A) using an extender cable.

4-39. Connect a Digital Voltmeter between the VPF output and ground on the Model 6600(A).

4-40. Connect a Digital Frequency Meter, with attenuator, if required, to RF Output of the Plug-in Unit.

4-41. Connect an RF Power Meter to the RF Output of the Plug-in Unit, noting effect of Frequency Meter on Power Meter reading. Account for power drain to Frequency Meter when adjusting RF Output of the Plug-in Unit.

4-42. Turn ON equipment and allow to warm up for one hour.

4-43. Follow steps in Table 4-2.

TABLE 4-2. ADJUSTMENT PROCEDURES

Function	Initial Settings	Adjust for Reading
1. Level Gain	Model 6600(A): Full Band, Sweep Time 0.1, RF Unmod, Trigger Internal. Plug-in: Internal Leveling	R80: Adjust for maximum leveled output with no amplitude modulation.
2. Unlevel Light Sensitivity	Model 6600(A): CW, AM Ext., Fo Mid-band. Plug-in: Internal Leveling	R53: Unlevel light turns on as Ext. AM signal is increased beyond 50 mV peak to peak, ±10 mV.
3. Low Frequency Adjust	Model 6600(A): CW, Unmodulated, Fo at Minimum Frequency. VPF: 0.000 volts	R33: Output Frequency = Minimum Frequency, ±1% as set by Fo.
4. High Frequency Adjust	Model 6600(A): CW, Unmodulated, Fo at Maximum Frequency. VPF = +10.000 volts.	R29: (If Low Frequency requires adjustment, adjust R33 before R29). Output Frequency = Maximum Frequency, ±1% as set by Fo.
5. M1, M2 Adjust. (F1, F2) for 6600(A)	Model 6600(A): Sweep = M1, M2; Manual Sweep ON, Control fully CCW. M1, at center band, M2 at high end of band.	R28: Frequency Meter reading = M1 setting, ±1%.
6. VPF Zero Adjust	Model 6600(A): CW Fo to give Full Band Low End Frequency on Frequency Meter. Digital Voltmeter on NA of Plug-in.	R12: Digital Voltmeter Reading = 0.000 volts, ±0.01 volts.
7. VPF Max Adjust	Model 6600(A): CW Fo to give Full Band High End Frequency on Frequency Meter.	R14: Digital Voltmeter Reading = +10.000 Volts, ±0.01 volts.
8. External Sample Sensitivity	Model 6600(A): Full Band, External Trigger, Sweep Time = 0.1 sec. Ext. Trig. Polarity to match External Trigger.	R1: Reading of RF Power Meter = 1 dB ±0.1 dB below specified leveled output of Plug-in Unit. This is a Panel Adjustment, to be set each time External Samples are used.
9. Level Control	Model 6600(A): Any Settings.	R3: Panel Adjustment. RF Output should vary with setting of R3 in both Level and Unlevel Modes, Sweep or CW.

SECTION V
PARTS LIST

5-1. INTRODUCTION.

5-2. This parts list section includes all pertinent data necessary to locate, identify, and procure additional parts for the equipment. Parts are listed alphanumerically by reference symbol and include all replaceable electronic items. In some cases, values, ratings and manufacturer sources shown are nominal and variations may be found. Satisfactory replacement may be made with either the listed component or an exact replacement of the part(s) removed from the equipment.

5-3. ORDERING INFORMATION.

5-4. The following instructions will aid in ordering parts from the parts list.

a. Address all inquiries or orders to:

CUSTOMER SERVICE
The Singer Company
3176 Porter Drive
Palo Alto, California 94304

b. Include the following information:

1) Model and Serial Number of instrument.
2) Singer Part Number.
3) Reference Symbol Number.
4) Description (as shown on Parts List).

5-5. HOW TO USE THE PARTS LIST.

5-6. Paragraphs 5-7 through 5-16 describe the use and meaning of the five columns included in the Parts List, Table 5-5. Table 5-1 lists the assemblies covered by the Parts List. Table 5-2 lists the manufacturer's code. Table 5-3 is a list of circuit reference symbols. Table 5-4 is a list of abbreviations used with this Parts List. Table 5-5 is a list of parts used in the Model 6610ED.

5-7 CIRCUIT REFERENCE.

5-8. The Circuit Reference Column contains an alphanumeric listing of parts as they appear on the equipment chassis, illustration, or schematic. The reference designation identifies the parts as to their component function in the instrument.

5-9 DESCRIPTION COLUMN.

5-10. The Description Column contains the identification of component parts, including all pertinent specifications. When the description column is used for a reference symbol for which no part exists, NOT ASSIGNED is placed in the column. In these instances, columns 3, 4, and 5 are left blank.

5-11. SINGER PART NUMBER COLUMN.

5-12. The Singer Part Number column contains the part number as designated by the Singer Company.

5-13 TRUE FSC NUMBER COLUMN.

5-14. The True FSC Number column references the manufacturer by an assigned code number, as listed in Federal Supply Code Handbook H4-2. For manufacturers not listed in the Handbook, a letter code will be assigned. Table 5-2 includes the manufacturer and his code designation.

5-15 TRUE MANUFACTURER'S PART NUMBER COLUMN.

5-16. The True Manufacturer's Part Number shown contains the part number as designated by the manufacturer of the part.

TABLE 5-5. REPLACEABLE PARTS MODEL 6610ED SERIES (CONTINUED)

CIRCUIT REFERENCE	DESCRIPTION	SINGER PART NO.	TRUE MFG. FSC NO.	TRUE MFG. PART NO.
A1	(Cont.)			
	RESISTORS			
R54	22.1 kΩ	59-22.1K	19701	MF5C-D-2212F
R55	10.0 kΩ	59-10.0K	19701	MF5C-D-1002F
R56	Factory Selected			
R57	4.02 kΩ	59-4.02K	19701	MF5C-D-4021F

TABLE 5-1. MODEL 6610ED SERIES

Circuit Reference	Description	Circuit Reference	Description
A1	Master Board	A4	Inner Panel Assembly
A2	RF Plate Assembly	A5	Front Panel Assembly
A3	Sampler		

TABLE 5-2. FEDERAL SUPPLY CODE FOR MANUFACTURERS

FMC No.	Name and Address of Vendor
IND-STD	Industry Standard. Order from any manufacturer.
03782	Singer Company, Alfred Operation, 3176 Porter Drive Palo Alto, Calif.
04713	Motorola Semiconductor Products, 5005 E. McDonnell Road, Phoenix, Arizona
11312	Teledyne Inc., 3165 Porter Drive, Palo Alto, California
13919	Burr Brown Research Corp., P.O. Box 11400, Tucson, Arizona
14655	Cornell-Dubilier Electric, 50 Paris Street, Newark, New Jersey
16453	Western Microwave Labs, 1045 Di Giulio Street, Santa Clara, California
18324	Signetics Corp., 811 East Argues, Sunnyvale, California
19701	Electra Mfg. Co., 800 North 21st, Independence, Kansas
24001	Advanced Microwave Labs, 937 Industrial Ave., Palo Alto, California
29083	Monsanto Electronics, 2710 Lafayette St., Santa Clara, California
31918	International Electro Exchange, 6529 Cambridge Street, Minneapolis, Minn.
31951	Triridge Corp., Route 151, Aliquippa, Pennsylvania
56289	Sprague Electric Co., 91 Marshall Street, North Adams, Massachusetts
72982	Erie Technological Products, Inc., 644 W. 12th Street, Erie, Pennsylvania
75042	IRC Inc., 401 N. Broad Street, Philadelphia, Pennsylvania
91637	Dale Electronics Inc., P.O. Box 608, Columbus, Nebraska

TABLE 5-3. REFERENCE SYMBOLS

AR	Amplifier, IC	P	Plug, Connector
AT	Attenuator, Isolator	Q	Transistor
C	Capacitor	R	Resistor
CR	Diode	S	Switch
DS	Lamp	T	Transformer
J	Jack, Connector	U	Integrated Circuit
K	Relay	Z	Miscellaneous Parts:
L	Coil		Ferrite Beads (RF Choke)

TABLE 5-4. ABBREVIATIONS

Cer.	Ceramic	%	± % if sign not shown
Comp.	Composition	P/O	Part of
Dep. Car.	Deposited Carbon	Pot.	Potentiometer
Elec.	Electrolytic, Aluminum	pF	Picofarad
Fact. Sel.	Factory Selected	RF	Radio Frequency
IND-STD	Industry Standard	Spec.	Special
k	Thousand	Tant.	Tantalum Electrolytic
m	0.001 (1/1000)	Var.	Variable
M	Million	W	Watts
MF	Metal Film	WW	Wirewound
Mfr	Manufacturer	Ω	Ohms
No.	Number	µF	Microfarads
0 TC	Zero Temperature Coefficient		

TABLE 5-5. REPLACEABLE PARTS MODEL 6610ED SERIES

CIRCUIT REFERENCE	DESCRIPTION	SINGER PART NO.	TRUE MFG. FSC NO.	TRUE MFG. PART NO.
A1	MASTER BOARD	952-874	03782	952-874
	CAPACITORS			
	NOTE: Unless otherwise noted capacitors are fixed ceramic.			
C1	33 pF ±2% 500V DM	150-2002-330EG0	14655	CD15ED330G03
C2	300 pF ±2% 500V DM	150-2002-301FG0	14655	CD151FD301G03
C3	NOT ASSIGNED			
C4	FACTORY SELECTED			
C5	0.047 ±10% 50V	12-73	72982	8131-M050-W5R-473M
C6 thru C8	See Parts List for Particular Plug-in			
C9	NOT ASSIGNED			
C10	Used in 6612ED only			
C11	1.0 µF ±10% 50V	12-94	72982	8131-M050-651-105M
C12	5 pF ±0.5 pF 500V DM	150-2002-050CD0	14655	CD15CD050D03
C13	33 pF ±2% 500V DM	150-2002-330EG0	14655	CD15ED330G03
C14, C15	12 pF ±5% 500V DM	150-2002-120CJ0	14655	CD15CD120J03
C16	0.1 µF ±10% 100V	12-72	72982	8131-100-W5R-104M
C17	10 µF -10% +50% 100 V Elec.	13-33	56289	39D106G100-DC-4
C18	0.047 µF ±10% 50V	12-73	72982	8131-M050-W5R-473M
C19	100 pF ±2% 500V DM	150-2002-101FG0	14655	CD15FD101G03
C20, C21	Factory Select			
C22	33 pF ±2% 500V DM	150-2002-330EG0	14655	CD15ED330G03
C23	1.0 µF ±10% 50V	12-94	72982	8131-M050-651-105M
	DIODES			
CR1	1N4148	154-0013-001	IND-STD	1N4148
CR2, CR3	NOT ASSIGNED			
CR4	Used only in 6612ED			
CR5 thru CR7	1N4148	154-0013-001	IND-STD	1N4148
CR8	1N4005	81-20	IND-STD	1N4005
CR9 thru CR11	1N4148	154-0013-001	IND-STD	1N4148
CR12	LED MV10B	81-276	29083	MV10B
CR13	1N4148	154-0013-001	IND-STD	1N4148

TABLE 5-5. REPLACEABLE PARTS MODEL 6610ED SERIES (CONTINUED)

CIRCUIT REFERENCE	DESCRIPTION	SINGER PART NO.	TRUE MFG. FSC NO.	TRUE MFG. PART NO.
A1	(Cont.)			
	RELAYS			
K1	DPST Reed Relay, 24 volt	158-0012-001	31951	220-200-24
	TRANSISTORS			
Q1	2N5255	81-267	IND-STD	2N5255
Q2	2N3904	556-146-989	IND-STD	2N3904
Q3	2N6178	153-5005-001	IND-STD	2N6178
Q4, Q5	2N5964	153-3033-001	IND-STD	2N5964
Q6	2N4889	153-3023-001	IND-STD	2N4889
Q7	2N5964	153-3033-001	IND-STD	2N5964
Q8	MJE3055	81-270	04713	MJE3055
Q9, Q10	NOT ASSIGNED			
Q11, Q12	2N3906	556-146-988	IND-STD	2N3906
Q13	2N699	84-1	IND-STD	2N699
Q14 thru Q16	2N3906	556-146-988	IND-STD	2N3906
Q17	2N3904	556-146-989	IND-STD	2N3904
Q18	2N699	84-1	IND-STD	2N699
Q19	2N3906	556-146-988	IND-STD	2N3906
Q20	2N5486	81-310	IND-STD	2N5486
Q21	2N3904	556-146-989	IND-STD	2N3904
	RESISTORS			
	NOTE: All resistors are fixed, metal film, 1/4 W, ±1% unless otherwise noted.			
R1	4.99 kΩ	59-4.99K	19701	MF5C-D-4991F
R2	1.0 kΩ	59-1.00K	19701	MF5C-D-1001F
R3	4.32 kΩ	59-4.32K	19701	MF5C-D-4321F
R4	1.50 kΩ	59-1.50K	19701	MF5C-D-1501F
R5	768 Ω	59-768	19701	MF5C-D-7680F
R6	3.40 kΩ	59-3.40K	19701	MF5C-D-3401F
R7	See Parts List for Particular Plug-in			
R8	40.2 kΩ	59-40.2K	19701	MF5C-D-4022F
R9	1.62 kΩ	59-1.62K	19701	MF5C-D-1621F
R10	10.0 Ω 1/2 W	56-10.0	19701	MF6C-D-10R0F

TABLE 5-5. REPLACEABLE PARTS MODEL 6610ED SERIES (CONTINUED)

CIRCUIT REFERENCE	DESCRIPTION	SINGER PART NO.	TRUE MFG. FSC NO.	TRUE MFG. PART NO.
A1	(Cont.)			
	RESISTORS			
R11	22.1 kΩ	59-22.1K	19701	MF5C-D-2212F
R12	Var. Trim, 2 kΩ ±5% 1 W	71-176	75042	205-208-2K
R13	20.0 kΩ	59-20.0K	19701	MF5C-D-2002F
R14	Var, Trim, 2 kΩ ±5% 1 W	71-176	75042	205-208-2K
R15	17.8 kΩ	59-17.8K	19701	MF5C-D-1782F
R16	NOT ASSIGNED			
R17, R18	See Parts List for Particular Plug-in			
R19	1.50 kΩ	59-1.50K	19701	MF5C-D-1501F
R20	15.0 kΩ	59-15.0K	19701	MF5C-D-1502F
R21	4.99 kΩ	59-4.99K	19701	MF5C-D-4991F
R22	2.21 kΩ	59-2.21K	19701	MF5C-D-2211F
R23	4.22 kΩ	59-4.22K	19701	MF5C-D-4221F
R24	36.5 kΩ	59-36.5K	19701	MF5C-D-3652F
R25	100 Ω	59-100	19701	MF5C-D-1000F
R26	10.0 Ω 1/2 W	56-10.0	19701	MF6C-D-10R0F
R27	100 kΩ	59-100K	19701	MF5C-D-1003F
R28, R29	Var, Trim, 1 kΩ ±5% 1 W	71-172	75042	205-208-1K
R30, R31	9.09 kΩ	59-9.09K	19701	MF5C-D-9091F
R32 thru R36	See Parts List for Particular Plug-in			
R37	4.02 kΩ	59-4.02K	19701	MF5C-D-4021F
R38, R39	See Parts List for Particular Plug-in			
R40	2.0 kΩ	59-2.00K	19701	MF5C-D-2001F
R41	100 Ω	59-100	19701	MF5C-D-1000F
R42	249 Ω 1/2 W	56-249	19701	MF6C-D-2490F
R43	2.0 Ω± 3% WW 5 W	61-41	91637	RH-5-2.0 Ω
R44	200 Ω	59-200	19701	MF5C-D-2000F
R45	See Parts List for Particular Plug-in			
R46	Factory Selected for 6612ED only			
R47 thru R51	NOT ASSIGNED			
R52	41.2 Ω 1/2 W	56-41.2	19701	MF6D-C-41R2F
R53	Var, Trim, 1 kΩ ±10% 3/4 W	71-105	75042	960-20-1K

TABLE 5-5. REPLACEABLE PARTS MODEL 6610ED SERIES (CONTINUED)

CIRCUIT REFERENCE	DESCRIPTION	SINGER PART NO.	TRUE MFG. FSC NO.	TRUE MFG. PART NO.
A1	(Cont.)			
	RESISTORS			
R54	22.1 kΩ	59-22.1K	19701	MF5C-D-2212F
R55	10.0 kΩ	59-10.0K	19701	MF5C-D-1002F
R56	Factory Selected			
R57	4.02 kΩ	59-4.02K	19701	MF5C-D-4021F
R58	2.21 kΩ	59-2.21K	19701	MF5C-D-2211F
R59	NOT ASSIGNED			
R60	1.58 kΩ	59-1.58K	19701	MF5C-D-1581F
R61	6.49 kΩ	59-6.49K	19701	MF5C-D-6491F
R62	1.21 kΩ	59-1.21K	19701	MF5C-D-1211F
R63	NOT ASSIGNED			
R64	2.21 kΩ	59-2.21K	19701	MF5C-D-2211F
R65	1.82 kΩ	59-1.82K	19701	MF5C-D-1821F
R66	2.21 kΩ	59-2.21K	19701	MF5C-D-2211F
R67	26.1 Ω	59-26.1	19701	MF5C-D-26R1F
R68	1.18 kΩ 1/2 W	56-1.18K	19701	MF6C-D-1181F
R69	4.99 kΩ	59-4.99K	19701	MF5C-D-4991F
R70	11.0 kΩ	59-11.0K	19701	MF5C-D-1102F
R71	4.99 kΩ	59-4.99K	19701	MF5C-D-4991F
R72	1.10 kΩ	59-1.10K	19701	MF5C-D-1101F
R73	100 Ω 1W	52-100	19701	MF7C-D-1000F
R74	10.0 Ω	59-10.0	19701	MF5C-D-1002F
R75	30.1 Ω	59-20.1	19701	MF5C-D-30R1F
R76	866 Ω	59-866	19701	MF5C-D-8660F
R77	1.0 kΩ	59-1.00K	19701	MF5C-D-1001F
R78	511 Ω	59-511	19701	MF5C-D-5110F
R79	100 kΩ	59-100K	19701	MF5C-D-1003F
R80	2 KΩ ±10% 3/4 W Var, Trim	71-95	75042	960-290-2K
R81, R82	See Parts List for Particular Plug-in			
R83	10.0 kΩ	59-10.0K	19701	MF5C-D-1002F
R84	402 kΩ	59-402K	19701	MF5C-D-4023F
R85	10.0 kΩ	59-10.0K	19701	MF5C-D-1002F
R86	5.49 kΩ	59-5.49K	19701	MF5C-D-5491F

TABLE 5-5. REPLACEABLE PARTS MODEL 6610ED SERIES (CONTINUED)

CIRCUIT REFERENCE	DESCRIPTION	SINGER PART NO.	TRUE MFG. FSC NO.	TRUE MFG. PART NO.
A1	(Cont.)			
	RESISTORS			
R87	6.81 kΩ	59-6.81K	19701	MF5C-D-6811F
R88	15.0 kΩ	59-15.0K	19701	MF5C-D-1502F
R89	See Parts List for Particular Plug-in			
R90	20 kΩ	59-20K	19701	MF5C-D-2002F
R91	1.0 kΩ 1/2W	56-1.00K	19701	MF6C-D-1001F
R92	7.50 kΩ	59-7.50K	19701	MF5C-D-7501F
R93	2.21 kΩ	59-2.21K	19701	MF5C-D-2211F
R94	15.0 kΩ	59-15.0K	19701	MF5C-D-1502F
R95	3.01 kΩ	59-3.01K	19701	MF5C-D-3011F
R96	Factory Selected			
R97	5.36 kΩ	59-5.36K	19701	MF5C-D-5361F
R98	4.75 kΩ	59-4.75K	19701	MF5C-D-4751F
R99	4.75 kΩ	59-4.75K	19701	MF5C-D-4751F
R100, R101	10.0 Ω 1/2 W	56-10.0	19701	MF6C-D-10R0F
R102	2.43 kΩ	59-2.43K	19701	MF5C-D-2431F
	INTEGRATED CIRCUITS			
U1	LM101A	84-1	18324	LM101A
U2	Op Amp, Low Noise	153-7056-001	13919	3500A
U3 thru U5	LM101A	84-1	18324	LM101A

TABLE 5-6. REPLACEABLE PARTS PECULIAR TO MODEL 6610ED

CIRCUIT REFERENCE	DESCRIPTION	SINGER PART NO.	TRUE MFG. FSC NO.	TRUE MFG. PART NO.
A1	MASTER BOARD (Most parts are listed under A1 P/N 952-874)	952-874-02	03782	952-874-02
	CAPACITORS			
C6 thru C8	600 µF - 10% +50% 6V Electrolytic	13-101	56289	39D607G006EJ4
	FUSES			
F1	Fuse, Open Circuit			
F2	Fuse 0.5 A 8 AG	121-31	75195	361.500
	RESISTORS			
	Note: All resistors are fixed, metal film, 1/4 W, 1% unless otherwise specified.			
R17	40.2 kΩ	59-40.2K	19701	MF5C-D-4022F
R18	8.06 kΩ	59-8.06K	19701	MF5C-D-8061F
R32	9.31 kΩ	59-9.31K	19701	MF5C-D-9311F
R33	Var, Trim, 5 kΩ ±5% 1 W	71-171	75042	205-208-5K
R34	3.57 kΩ	59-3.57K	19701	MF5C-D-3571F
R35 thru R38	442 Ω	59-442	19701	MF5C-D-4420F
R39	280 Ω	59-280	19701	MF5C-D-2800F
R45	5 Ω ± 1% WW 5 W	61-42	91637	RH-5-5.0 Ω
R81	2.74 kΩ	59-2.74K	19701	MF5C-D-2741F
R82	10.0 kΩ	59-10.0K	19701	MF5C-D-1002F
R89	4.99 kΩ	59-4.99K	19701	MF5C-D-4991F
A2	RF PLATE ASSEMBLY	952-789	03782	952-789
AT1	RF Isolator	252-20	16453	2JC1020
AT2	Attenuator PIN Diode	252-18	03782	252-18
CR1	Diode 1N4748A	81-286	IND-STD	1N4748A
Y1	YIG RF Oscillator	112-017	03782	112-017
A3	SAMPLER, 1-4.2 GHz 10 dB	952-287	03782	952-276
CR1	RF Detector	901-304	03782	901-304
DC	Directional Coupler, 10 dB	952-428	03782	952-428

TABLE 5-7. REPLACEABLE PARTS PECULIAR TO MODEL 6611ED

CIRCUIT REFERENCE	DESCRIPTION	SINGER PART NO.	TRUE MFG. FSC NO.	TRUE MFG. PART NO.
A1	MASTER BOARD (Most Parts are listed under A1 P/N 952-874)	952-874-03	03782	952-874-03
	CAPACITORS			
C6 thru C8	600 µF, -10% +50%, 6 V Electrolytic	13-101	56289	39D607G006EJ4
	FUSES			
F1	Fuse, Open Circuit			
F2	Fuse, 1.0 A 8 AG	121-30	75195	361001.
	RESISTORS			
	Note: All resistors are Fixed, Metal Film, 1/4 W, 1% unless otherwise noted.			
R17	40.2 kΩ	59-40.2K	19701	MF5C-D-4022F
R18	8.06 kΩ	59-8.06K	19701	MF5C-D-8061F
R32	10.0 kΩ	59-10.0K	19701	MF5C-D-1002F
R33	Var, Trim, 2 kΩ ±5% 1 W	71-176	75042	205-208-2K
R34	3.48 kΩ	59-2.48K	19701	MF5C-D-3481F
R35	475 Ω	59-475	19701	MF5C-D-4750F
R36	475 Ω	59-475	19701	MF5C-D-4750F
R38	475 kΩ	59-475K	19701	MF5C-D-4753F
R39	374 Ω	59-374	19701	MF5C-D-3740F
R45	2.4 Ω ±1% WW 5 W	61-40	91637	RH-5-2.4 Ω
R81	1.0 kΩ	59-1.00K	19701	MF5C-D-1001F
R82	27.4 kΩ	59-27.4K	19701	MF5C-D-2742F
R89	4.99 kΩ	59-4.99K	19701	MF5C-D-4991F
A2	RF PLATE ASSEMBLY	952-792	03782	952-792
AT1	RF Isolator	252-21	24001	0N1012
AT2	Attenuator PIN Diode	252-18	03782	252-18
CR1	Diode 1N4748A	81-286	IND-STD	1N4748A
Y1	YIG RF Oscillator	113-016	03782	113-016
A3	SAMPLER, 1-4.2 GHz 10 dB	952-287	03782	952-287
CR1	RF Detector	901-304	03782	901-304
DC	Directional Coupler, 10 dB	952-428	03782	952-428

TABLE 5-8. REPLACEABLE PARTS PECULIAR TO MODEL 6612ED

CIRCUIT REFERENCE	DESCRIPTION	SINGER PART NO.	TRUE MFG. FSC NO.	TRUE MFG. PART NO.
A1	MASTER BOARD (Most Parts are Listed under A1 P/N 952-874)	952-874-04	03782	952-874-04
	CAPACITORS			
C6 thru C8	600 µF, -10%, +50%, 6 V, Electrolytic	13-101	56289	39D607G006EJ4
C10	0.1 µF, ±10%, 100 V, Ceramic	12-72	72982	8131-100-W5R-104M
	DIODES			
CR4	1N4735A	81-91	IND-STD	1N4735A
	FUSES			
F1	Fuse, 0.5 A, 8 AG	121-31	75195	361.500
F2	Fuse, 1.5 A, 8 AG	121-32	75195	36101.5
	RESISTORS			
	Note: All resistors are Fixed, Metal Film, 1/4 W, 1% unless otherwise noted.			
R17	40.2 kΩ	59-40.2K	19701	MF5C-D-4022F
R18	8.06 kΩ	59-8.06K	19701	MF5C-D-8061F
R32	10.5 kΩ	59-10.5K	19701	MF5C-D-1052F
R33	Var, Trim, 1 kΩ, ±5%, 1 W	71-172	75042	205-208-1K
R34	3.48 kΩ	59-3.48K	19701	MF5C-D-3481F
R35	499 Ω	59-499	19701	MF5C-D-4990F
R36	499 Ω	59-499	19701	MF5C-D-4990F
R38	499 kΩ	59-499K	19701	MF5C-D-4993F
R39	392 Ω	59-392	19701	MF5C-D-3920F
R45	2 Ω, ±1%, WW, 5 W	61-46	91637	RH-5-2.0 Ω
R81	1.0 kΩ	59-1.00K	19701	MF5C-D-1001F
R82	43.2 kΩ	59-43.2K	19701	MF5C-D-4322F
R89	4.99 kΩ	59-4.99K	19701	MF5C-D-7991F
A2	RF PLATE ASSEMBLY	952-819	03782	952-819
AT1	RF Isolator, 4-8 GHz, F-In/M-Out	252-23	24001	CN1004
AT2	Attenuator PIN Diode	252-18	03782	252-18
CR1	Diode 1N4734A	81-77	IND-STD	1N4734A
CR2	Diode 1N4745A	81-312	IND-STD	1N4745A
Y1	YIG RF Oscillator	113-024	03782	113-024
A3	SAMPLER 3.5-12.4 GHz, 10 dB	952-288	03782	952-288
CR1	RF Detector	901-304	03782	901-304
DC	Directional Coupler, 10 dB	952-427	03782	952-427

TABLE 5-9. REPLACEABLE PARTS PECULIAR TO MODEL 6615ED

CIRCUIT REFERENCE	DESCRIPTION	SINGER PART NO.	TRUE MFG. FSC NO.	TRUE MFG. PART NO.
A1	MASTER BOARD (Most Parts are listed under A1 P/N 952-874)	952-874-05	03782	952-874-05
	CAPACITORS			
C6 thru C8	500 µF, -10%, +50%, 10 V, Electrolytic	13-104	56289	39D507G010EJ4
	FUSES			
F1	Fuse, 1.0 A, 8 AG	121-30	75195	361001.
F2	Fuse, 1.5 A, 8 AG	121-32	75195	36101.5
	RESISTORS			
	Note: All Resistors are Fixed, Metal Film, 1/4 W, 1% unless otherwise noted.			
R17	22.1 kΩ	59-22.1K	19701	MF5C-D-2212F
R18	6.81 kΩ	59-6.81K	19701	MF5C-D-6811F
R32	4.99 kΩ	59-4.99K	19701	MF5C-D-4991F
R33	NOT ASSIGNED			
R34	2.67 kΩ	59-2.67K	19701	MF5C-D-2671F
R35	475 Ω	59-475	19701	MF5C-D-4750F
R36	475 Ω	59-475	19701	MF5C-D-4750F
R38	475 kΩ	59-475K	19701	MF5C-D-4753F
R39	476 Ω	59-476	19701	MF5C-D-4760F
R45	2 Ω, ±1%, WW, 5W	61-46	91637	RH-5-2.0 Ω
R81	1.0 kΩ	59-1.00K	19701	MF5C-D-1001F
R82	43.2 kΩ	59-43.2K	19701	MF5C-D-4322F
R89	4.99 kΩ	59-4.99K	19701	MF5C-D-4991F
A2	RF PLATE ASSEMBLY	952-882	03872	952-882
AT1	RF Isolator 8-12 GHz, M-In/F-Out	252-24	11312	T8M-43A-1B
AT2	Attenuator PIN Diode	252-18	03782	252-18
CR1	Diode 1N4005	81-20	IND-STD	1N4005
CR2	Diode 1N4005	81-20	IND-STD	1N4005
CR3	Diode 1N4746A	81-275	IND-STD	1N4746A
CR4	Diode 1N4746A	81-275	IND-STD	1N4746A
Y1	YIG RF Oscillator	113-007	03782	113-007
A3	SAMPLER, 3.5-12.4 GHz, 10 dB	952-288	03872	952-288
CR1	RF Detector	901-304	03782	901-304
DC	Directional Coupler, 10 dB	952-427	03782	952-427

TABLE 5-10. REPLACEABLE PARTS PECULIAR TO MODEL 6616ED

CIRCUIT REFERENCE	DESCRIPTION	SINGER PART NO.	TRUE MFG. FSC NO.	TRUE MFG. PART NO.
A1	MASTER BOARD (Most Parts are listed under A1 P/N 952-874)	952-874-06	03782	952-874-06
	CAPACITORS			
C6 thru C8	500 µF, -10%, +50%, 10 V, Electrolytic	13-104	56289	39D507G010J4
	FUSES			
F1	Fuse, 1.0 A, 8 AG	121-30	75195	361001.
F2	Fuse, 2.0 A, 8 AG	121-33	75195	361002.
	RESISTORS			
	Note: All Resistors are Fixed, Metal Film, 1/4 W, 1% unless otherwise noted.			
R17	18.2 kΩ	59-18.2K	19701	MF5C-D-1822F
R18	6.49 kΩ	59-6.49K	19701	MF5C-D-6491F
R32	4.12 kΩ	59-4.12K	19701	MF5C-D-4121F
R33	Var, Trim, 1 kΩ, ±5%, 1 W	71-172	75042	205-208-1K
R34	2.43 kΩ	59-2.43K	19701	MF5C-D-2431F
R35	536 Ω	59-536	19701	MF5C-D-5360F
R36	536 Ω	59-536	19701	MF5C-D-5360F
R38	499 kΩ	59-499K	19701	MF5C-D-4993F
R39	665 Ω	59-665	19701	MF5C-D-6650F
R45	1.8 Ω, ±1%, WW, 5 W	61-38	91637	RH-5-1.8 Ω
R81	1.0 kΩ	59-1.00K	19701	MF5C-D-1001F
R82	43.2 kΩ	59-43.2K	19701	MF5C-D-4322F
R89	10.0 kΩ	59-10.0K	19701	MF5C-D-1002F
A2	RF PLATE ASSEMBLY	952-881	03782	952-881
AT1	RF Isolator, 12-18 GHz, Male	252-25	11312	T12S-43T-4
AT2	Attenuator PIN Diode	252-18	03782	252-18
CR1	Diode 1N4005	81-20	IND-STD	1N4005
CR2	Diode 1N4005	81-20	IND-STD	1N4005
CR3	Diode 1N4746A	81-275	IND-STD	1N4746A
CR4	Diode 1N4746A	81-275	IND-STD	1N4746A
Y1	YIG RF Oscillator	113-008	03782	113-008
A3	SAMPLER, 12.4-18 GHz	950-892	03782	950-892
CR1	Detector	251-3	28480	P424A
DC	Directional Coupler, 10 dB	250-17	03782	250-17

TABLE 5-11. REPLACEABLE PARTS IN FRONT PANEL ASSEMBLIES

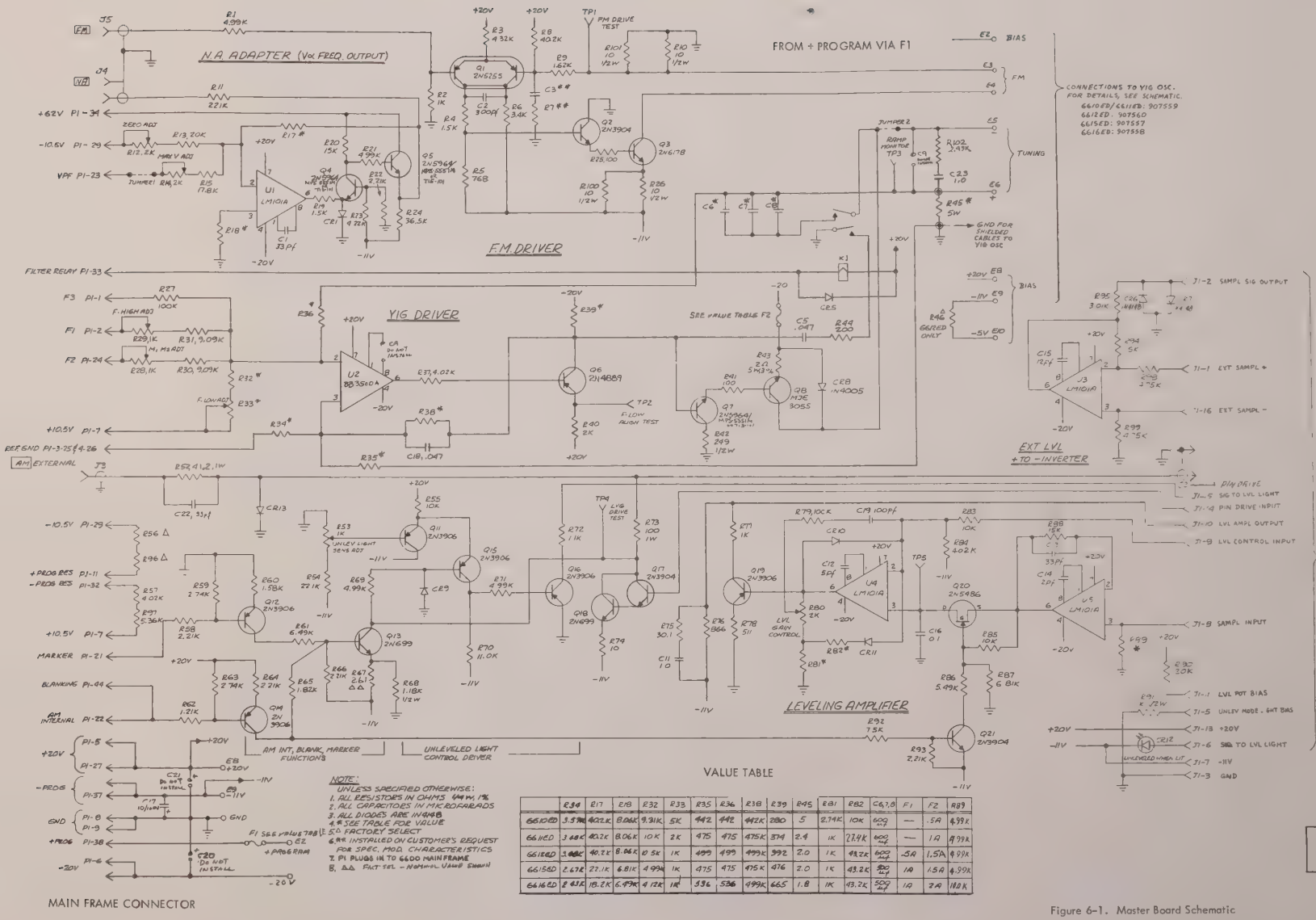
CIRCUIT REFERENCE	DESCRIPTION	SINGER PART NO.	TRUE MFG. FSC NO.	TRUE MFG. PART NO.
A4	INNER PANEL ASSEMBLY	952-382	03782	952-382
DS1, DS2	Lamp, #388	126-26	IND-STD	388
R3A, B	Resistor, Dual Pot, 1 k, ±10%, 0.5 W	912-185	03782	912-185
S4	Switch, Slide, DPDT	913-919	03782	913-919
A5	FRONT PANEL ASSEMBLY	952-298	03782	952-298
R1	Resistor, Trimpot, 10 kΩ, ±10%, 3/4 W	71-93	75042	960-290-10K
R2	Resistor, Fixed, 7.5 k, ±1%, 1/4 W, MF	59-7.50K	19701	MF5C-D-7501F
R3	Resistor, Fixed, 499 Ω, ±1%, 1/4 W, MF	59-499	19701	MF5C-D-4990F
S1 thru S3	Switch, Triple, DPDT, PB	101-40	31918	3XF12.5-2U-GR-D

SECTION VI

SUPPLEMENTARY SCHEMATIC DIAGRAMS

6-1. SUPPLEMENTARY SCHEMATICS BY MODULE RATHER THAN BY FUNCTION.

6-2. These schematics are included to help signal tracing, where signals may flow through several boards between two functional schematics. The paths are indicated, point by point, at entrance and exit terminals of the Functional Schematics in Section IV.



NOTE:
UNLESS SPECIFIED OTHERWISE:
1. ALL RES/STORS IN OHMS 5% 1/4W, 1%
2. ALL CAPACITORS IN MICROFARADS
3. ALL DIODES ARE 1N4148
4. * SEE TABLE FOR VALUE
5. Δ FACTORY SELECT
6. ## INSTALLED ON CUSTOMER'S REQUEST FOR SPEC. MOD. CHARACTERISTICS
7. P1 PLUGS IN TO 6600 MAINFRAME
8. ΔΔ FACTSEL - NOMINAL VALUE SHOWN

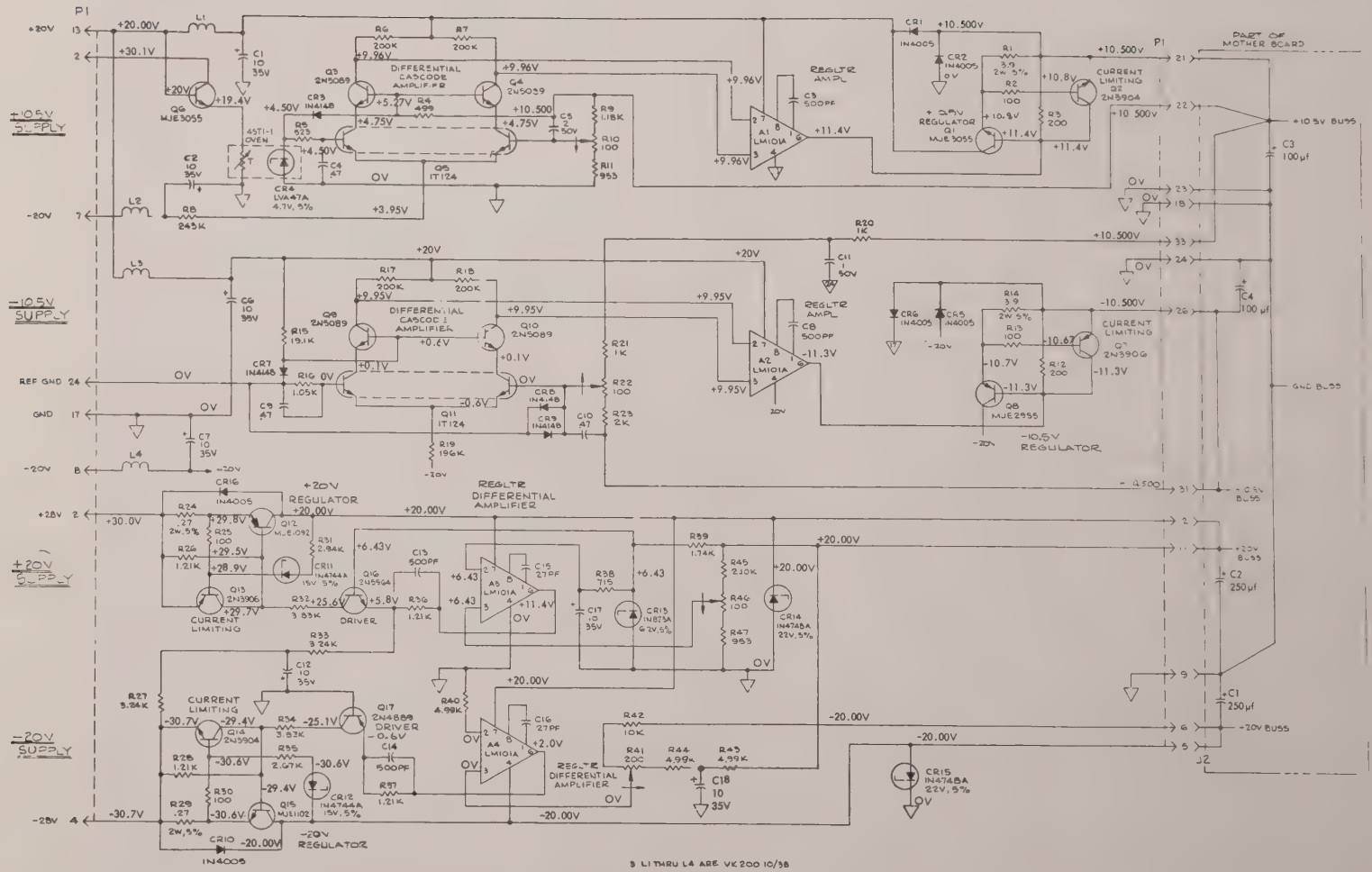
VALUE TABLE

	E34	E17	E18	E32	E33	E35	E36	E38	E39	E45	E81	E82	C6,7,8	F1	F2	R89
6610ED	3.57K	40.2K	8.06K	9.31K	5K	442	442	442K	280	5	2.74K	10K	600 mA	—	.5A	4.99K
6611ED	3.48K	40.2K	8.06K	10K	2K	475	475	475K	374	2.4	1K	2.74K	600 mA	—	1A	4.99K
6612ED	3.48K	40.2K	8.06K	10.5K	1K	499	499	499K	392	2.0	1K	43.2K	600 mA	.5A	1.5A	4.99K
6615ED	2.67K	27.1K	6.81K	4.99K	1K	475	475	475K	476	2.0	1K	43.2K	800 mA	1A	1.5A	4.99K
6616ED	2.83K	18.2K	6.49K	4.12K	1K	536	536	499K	665	1.8	1K	43.2K	500 mA	1A	2A	10.0K

A1

6 - 1.

Figure 6-1. Master Board Schematic



NOTES: UNLESS OTHERWISE SPECIFIED
1. ALL RESISTOR VALUES ARE IN OHMS 1/4W, 1%.
2. ALL CAPACITOR VALUES ARE IN MICROFARADS.
3. L1 THRU L4 ARE VK200 10/38

6-1

Figure 6-1. Schematic Diagram Regulator Board **A2**

SHIPMENT DAMAGE CLAIM

The instrument should be tested as soon as it is received. If it fails to operate properly or is damaged in any way, a claim must be filed with the carrier. Have carrier agent inspect damage to instrument and packing crate and forward us a copy of his written report. You will then be advised of replacement or repair arrangements and disposition of the equipment. Please include model number, type number and serial number when referring to this instrument for any reason.

REPACKING FOR SHIPMENT

The instrument should be packed in the original carton. If unusable or not available, use a wooden box with approximately three inches of excelsior or other shock-absorbing material surrounding the instrument. If desired, packing services of a local transfer and storage company may be employed.

SINGER
INSTRUMENTATION

CHAMPION CLASP NO. 55 6x9

MP MASTER
MA31759